20th ANNIVERSARY ISSUE

ASTRONOMY

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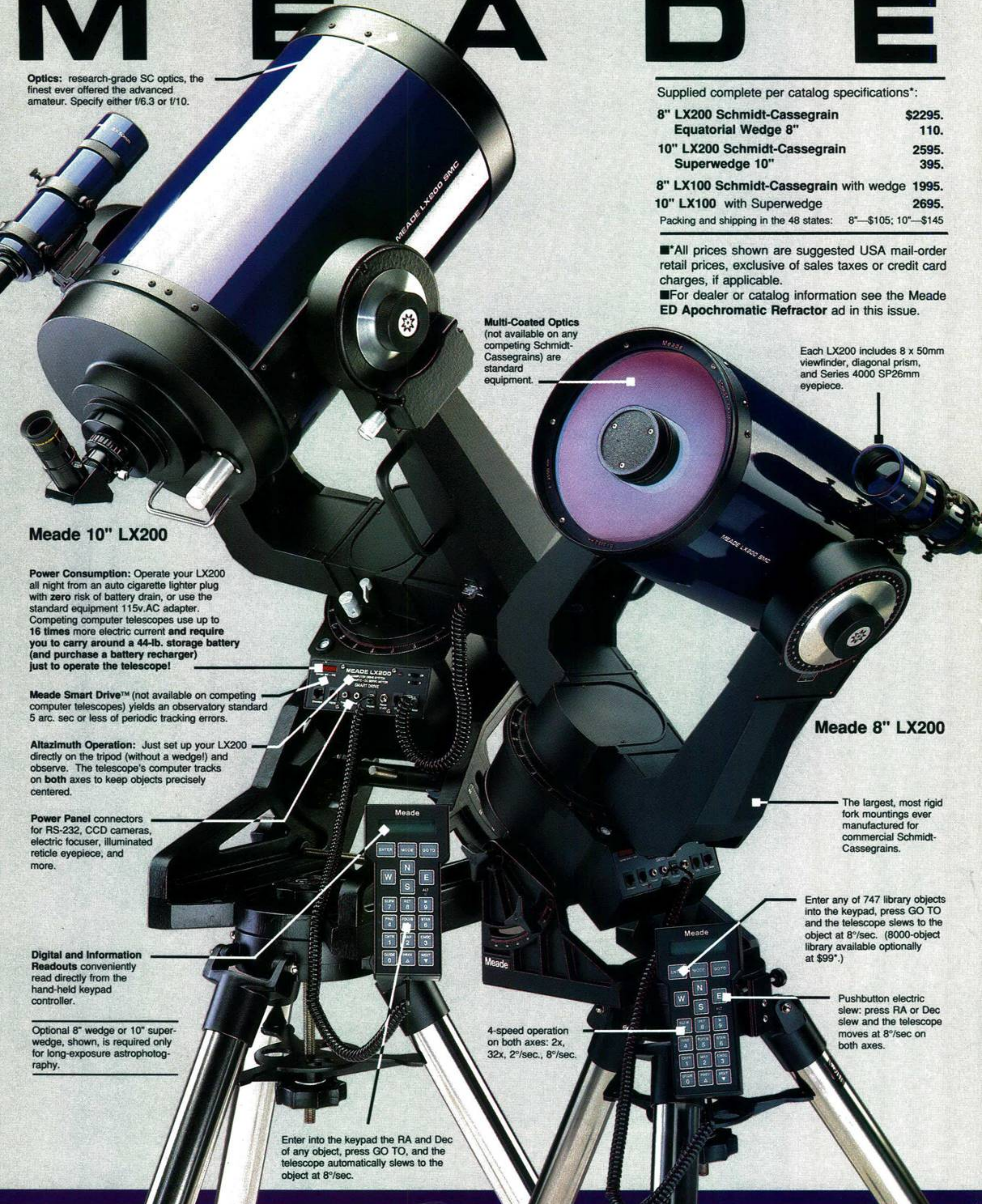
■*All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

■For dealer or catalog information see the Meade **ED Apochromatic Refractor** ad in this issue.



Optics: research-grade SC optics, the finest ever offered the advanced amateur. Specify either f/6.3 or f/10.

Multi-Coated Optics (not available on any competing Schmidt-Cassegrains) are standard equipment.

Each LX200 includes 8 x 50mm viewfinder, diagonal prism, and Series 4000 SP26mm eyepiece.

Meade 10" LX200

Power Consumption: Operate your LX200 all night from an auto cigarette lighter plug with **zero** risk of battery drain, or use the standard equipment 115v.AC adapter. Competing computer telescopes use up to **16 times** more electric current **and require you to carry around a 44-lb. storage battery (and purchase a battery recharger) just to operate the telescope!**

Meade Smart Drive™ (not available on competing computer telescopes) yields an observatory standard 5 arc. sec or less of periodic tracking errors.

Altazimuth Operation: Just set up your LX200 directly on the tripod (without a wedge!) and observe. The telescope's computer tracks on **both** axes to keep objects precisely centered.

Power Panel connectors for RS-232, CCD cameras, electric focuser, illuminated reticle eyepiece, and more.

Digital and Information Readouts conveniently read directly from the hand-held keypad controller.

Optional 8" wedge or 10" superwedge, shown, is required only for long-exposure astrophotography.

Meade 8" LX200

The largest, most rigid fork mountings ever manufactured for commercial Schmidt-Cassegrains.

Enter any of 747 library objects into the keypad, press GO TO and the telescope slews to the object at 8°/sec. (8000-object library available optionally at $99*.)

Pushbutton electric slew: press RA or Dec slew and the telescope moves at 8°/sec on both axes.

4-speed operation on both axes: 2x, 32x, 2°/sec., 8°/sec.

Enter into the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8°/sec.

LX200 SCHMIDT-CASSEGRAINS

The largest-selling serious telescopes in the world.

Now you can buy the most advanced 8" and 10" Schmidt-Cassegrains ever produced, at a price directly competitive with other SCT's offering only a fraction of the features!

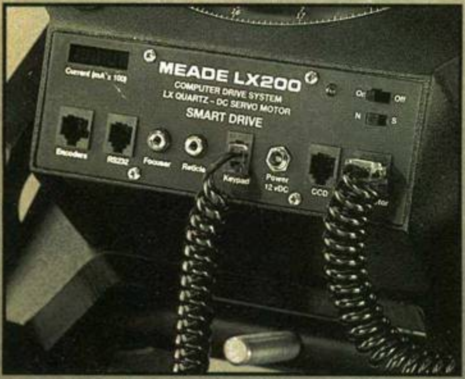
Meade LX200 SCT's offer a revolutionary departure from any other SCT's ever made available. Consider the **standard specifications** of these telescopes:

New Heavy-Duty Fork Mounts—The largest, most rigid in the industry. *Meade 8" and 10" LX200 fork mounts yield the lowest damping times of any SC fork mounts available.* Large 4"-diameter polar ball bearings complemented by DC-servo-motor-driven worm gears on ***both*** telescope axes permit observatory-level precision in tracking, guiding, and slewing.

100% Computer-Controlled Operation—All-new Meade LX200 microprocessor-controlled drive systems offer an incredible array of features:

■**Four-speed operation on both telescope axes** simultaneously, including (a) photo-guiding (at **2x** sidereal rate); (b) image centering and microslewing in the main telescope (at **32x** sidereal rate); (c) image centering in the viewfinder (at **2°** per sec.); or fast-slew of the main telescope across the skies (at **8°** per sec.).

■**Pushbutton Electric Slew**—Press RA or Dec slew, east or west, north or south, and the telescope moves at 8° per sec. on both axes. As you near a desired object, flip to 2° per sec. slew, to center the object in the field. The observer need never touch the telescope in moving from one object to another. (Of course, if you wish, the telescope may be moved manually as well.)



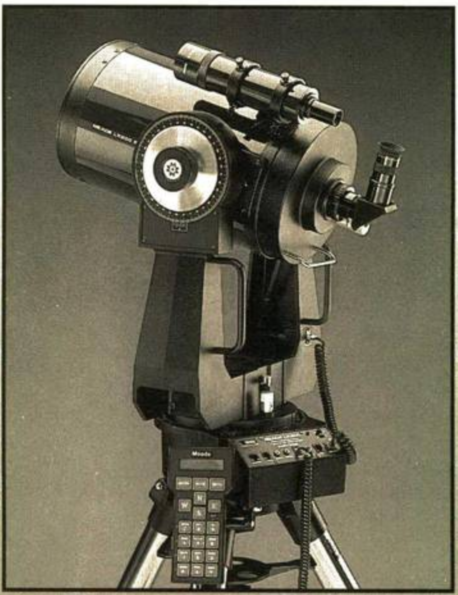
■**Digital Readouts** on both axes, read from the handheld Electronic Command Center (ECC).

■**GO TO Capability**—Enter the RA and Dec of an object into the keypad of the ECC, press GO TO, and the telescope automatically slews to the object at 8° per sec., centering it in the field.

■**747-Object Built-in Library**—Enter any of the 110 Messier objects, 278 of the finest NGC objects, 351 stars (doubles, variables, polar reference stars), or one of the 8 planets, from Mercury to Pluto, press GO TO, and the telescope slews at 8° per sec. to the object with uncanny precision. For $99* add the 8000-object Meade CNGC library, a 30-second plug-in.

■**Permanently programmable (PPEC) Smart Drive**™, capable of reducing periodic drive errors to 5 arc. sec. or less.

Legendary Meade Super Multi-Coated f/6.3 or f/10 Schmidt-Cassegrain Optics—Now you can choose either wide-field f/6.3 or classical f/10 Meade US-made SC optics **at the same price.** Either way, you'll be buying the finest Schmidt-Cassegrain optical system available, a system that yields razor-sharp stellar images and high-resolution observing of the Moon, planets, and deep-space, from the World's leading manufacturer. Meade exclusive Super Multi-Coatings on both sides of the correcting plate assure maximum light transmission and contrast.



Altazimuth Mode Operation—For all visual observing applications, and for lunar and planetary photography, Meade LX200's may be set up in the altazimuth mode, without any equatorial wedge—just attach the telescope's drive base directly to the tripod, use the fast 1-star alignment procedure, and the telescope's computer actuates 2-axis tracking that keeps objects precisely centered in the field, even at high powers, during the entire observing session. For long exposure photography (longer than about 5 minutes) altazimuth-induced field rotation requires an equatorial wedge, which may be purchased separately.

Fast Polar Alignment—Center two reference stars in the telescopic field and the telescope's computer tells you exactly what telescope controls to actuate for precise polar alignment in the equatorial mode in less than a minute.

The widest array of keypad and power-panel control functions—In addition to the microprocessor-controlled operations listed above, the handheld ECC and the telescope's power panel permit: readout of sidereal or local time; actuation of the optional electric focuser; crossline brightness control of an illuminated reticle eyepiece; direct plug-in of popular CCD autoguiders/imagers; and more than 14 other telescope functions.

MEADE LX100 SCHMIDT-CASSEGRAINS

Observers not requiring the sophistication of the LX200 electronics may wish to consider an 8" or 10" LX100 model SCT instead. Meade LX100's include the exact same heavy-duty fork mounts of their LX200 counterparts, but with a microfine declination tangent arm control in place of the LX200's motorized worm gear, and with a 2-speed drive in place of the LX200's 4-speed drive; optical tubes and coatings are identical. Standard LX100 features include:

■ Handheld Electronic Command Center—With 2-speed operation, **2x** for photo-guiding and **32x** for image centering and microslewing in the main telescope. (With the optional DC-servo declination motor installed, these speeds are operational on both telescope axes.)

■ Permanently programmable (PPEC) Smart Drive, as described above.

Complete LX100 and LX200 Telescopes

Specifications: 8" and 10" LX200's—Each complete telescope includes: 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount, with 4" polar ball bearing, dual-axis 5.75" worm-gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld keypad Electronic Command Center, with digital readout display, PPEC Smart Drive, four-speed drive control on both axes, GO TO controller, and 747-object software library; 25 ft. power cords for telescope operation from either 12 v. DC auto cigarette lighter plug or 115v.AC; 8 x 50mm viewfinder with crosshairs; diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece; variable-height field tripod; new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

Specifications: 8" and 10" LX100's—Each complete telescope includes 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, 5.75" RA worm gear, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld pushbutton Electronic Command Center with PPEC Smart Drive and 2-speed drive control; 25 ft. power cords for telescope operation from either 12v. DC auto cigarette lighter plug or from 115v. AC; viewfinder: 6 x 30mm (8") or 8 x 50mm (10"); diagonal prism (1.25"); Series 4000 Plössl 26mm eyepiece; variable-height field tripod; equatorial wedge (8") or Superwedge (10"); new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

Meade Instruments has moved!

Effective May 1, 1993, Meade Instruments has moved to new office and manufacturing facilities in Irvine, Calif., about 10 miles from our previous location. The new 56,400 sq. ft. Meade facility is the world's largest, most advanced commercial telescope manufacturing operation. Please note new address, telephone, and FAX numbers below.

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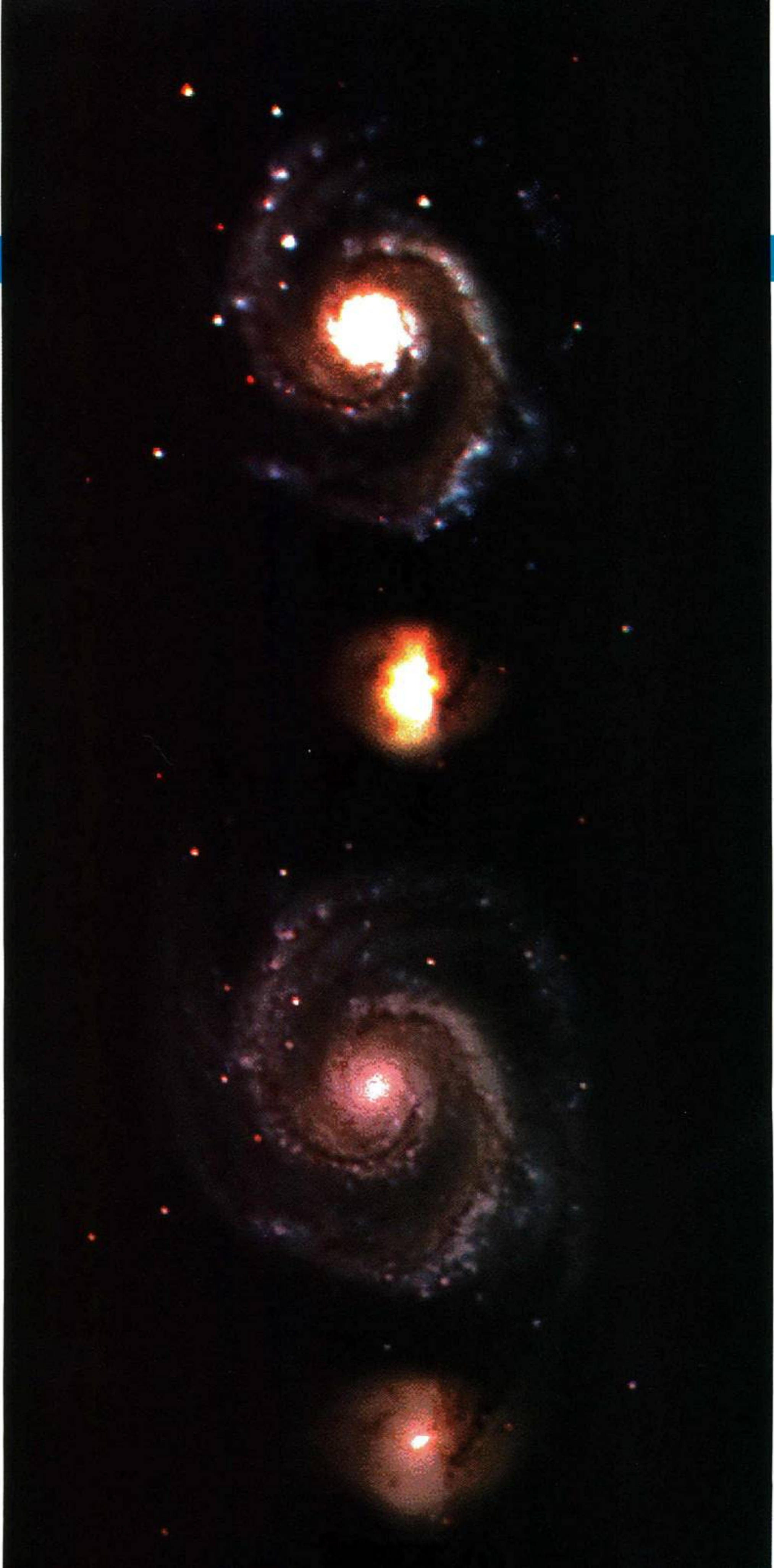
THE FUTURE OF AMATEUR ASTRONOMY will see the proliferation of CCDs and image processing on home computers, allowing amateurs to produce images with greater detail and contrast. For example, the bottom image of M51 was processed with new state-of-the-art computer software and shows much more detail than the conventionally processed image at top. For more on what the future holds for backyard astronomy, see page 13.



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ON THE COVER: NASA once relied on expensive trailblazing spacecraft like Voyager 2, shown several years from now as it crosses into interstellar space, but the future hinges more on low-cost missions than in trying to duplicate the expensive trailblazers (see page 38). NASA artwork by Pat Rawlings/SAIC.

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The Audit Bureau

Letters

ASTRONOMY's 20th Anniversary

In celebration of ASTRONOMY's 20th anniversary we are publishing a special section of letters in which readers forecast the future of amateur and professional astronomy.

Congratulations on ASTRONOMY's 20th anniversary. Having seen the progress astronomy as a subject has made over the past 20 years, the natural question is "Where will astronomy (professional and amateur) be in 20 years?"

With regard to professional astronomy, the coming two decades should be a golden era for our science. Astronomers will not only have routine access to many super-large telescopes in the 10-meter class, the telescopes' output will be enormously increased by modern detectors and computer-controlled devices.

One such device is the charge-coupled device (CCD), with its nearly optimal quantum efficiency. Multifiber, hydra-headed spectrographs will also enormously increase the efficiency of telescopes of all sizes by making possible the simultaneous observation of a large number of stars or galaxies. In my generation, producing redshifts for a few hundred galaxies by direct photography or image intensifiers was a multi-year (even multi-decade) project. Now astronomers will be able to obtain spectra of the same number of objects in just one night of work.

It is also easy to predict that near-instantaneous worldwide communication by electronic mail will increase the quick distribution and discussion of new data. (Even today e-mail is flooding me day and night with updates on Supernova 1993J in the galaxy M81.) Before long, printed publications of astronomical research papers may become obsolete. Many research papers take a year to reach print today, whereas a century ago short communications to *Astronomische Nachrichten* appeared within 2 to 4 weeks. To beat this bottleneck most institutions are already distributing preprints, which means the printed document is obsolete by the time it appears. Compact disks (CD-ROMs) will become the libraries of the future and replace the large plate stacks for which some observatories have grown famous.

I suspect that before too long astronomers will operate distant telescopes by remote control from the comfort of their offices, as recent successful experiments suggest. This will save a lot of wear and tear on astronomers who should spend more time thinking and reducing data and less time facing the hazards of air travel and subsidizing the airlines. "Join astronomy and see the world" cannot be our motto much longer.

The coming two decades should be a golden era for our science.

This may, in fact, become an economic necessity as the unrelenting pressure of the population explosion on resources becomes increasingly unbearable. I can't imagine what will happen well beyond 20 years from now, in a world struggling with the burden of 10 *billion* people and, possibly, one million astronomers. — *Gerard de Vaucouleurs, the University of Texas at Austin, Austin, Texas*

Observational evidence has been building that astronomy and physics took a wrong turn more than 60 years ago by mistakenly assuming all extragalactic redshifts were due to Doppler recession. Among other consequences this has led to an incorrect big bang cosmology. This in turn feeds back into physics, for example in the partial justification for building an $8.25 billion supercollider to study a mythical big bang creation event. Whole institutes have been founded to study "missing" matter which is really an invention needed to reconcile the contradiction of observation with present theory.

Meanwhile, professional journals increasingly censor the "discordant" observations and discussion that could lead to correction of faulty assumptions and mending of theories. The journals explode with processed data — leading inexorably to electronic publishing — in turn to be read by computers (what else?). The only real information begins to appear in alternative journals, small scraps of paper passed from hand to hand or by word of mouth.

The next 20 years? It took 1,800 years to replace the Ptolemaic system.

But this time I would predict a slightly faster reform. Individual scientists will, in increasing numbers, accept more general, and therefore more correct, solutions of the equations of general relativity. The solutions will fit the observations with fewer adjustable parameters and require a continuous creation, a nonexpanding universe of indefinite age and size. Quasars will be understood as local creation events and begin to unify the understanding of quantum and classical mechanics. — *Halton C. Arp, Max-Planck Institut für Astrophysik, Munich, Germany*

I predict that many of the most popular buzz words, such as dark matter, black holes, and mergers, will fall out of favor. This means that they will appear in many fewer published research papers. The first because we will find an alternate explanation for the effects that led us to propose dark matter. The last two because they will be found to be much less common than is currently believed.

Many ASTRONOMY readers are familiar with the compact galaxy groups Stephan's Quintet and Seyfert's Sextet. These groups pose very strong challenges to current ideas, both conventional and unconventional. The galaxy groups are thought to merge rapidly because they are so dense. Yet there is little evidence for merging. They also contain too many discordant redshift

[continued on page 12]

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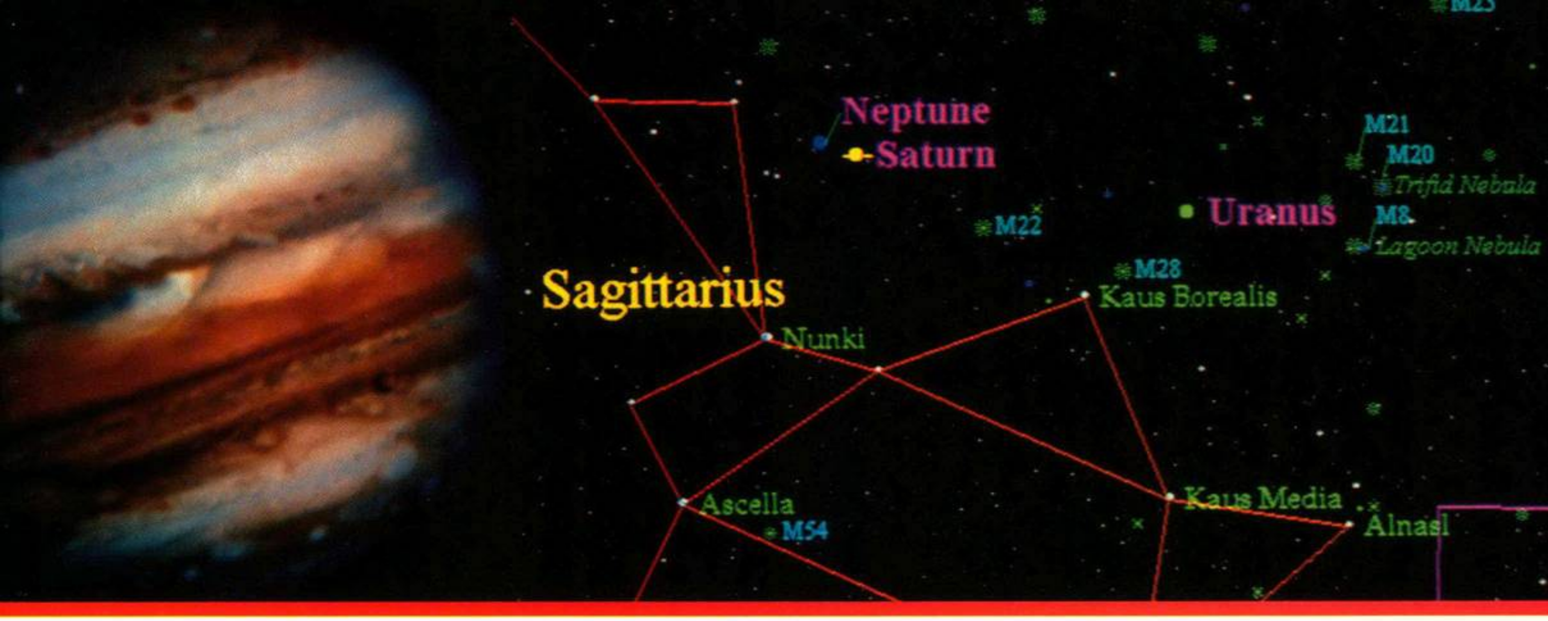
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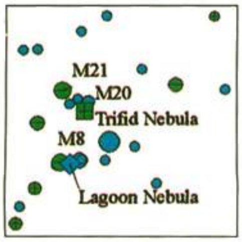

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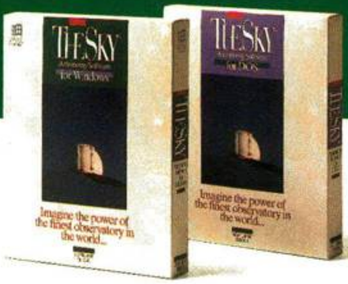
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Extended through July 31, 1993, you can receive Meade premium-grade Series 4000 eyepieces absolutely FREE! Just buy any of the eyepieces below at the regular price, and your Meade dealer will include the listed free eyepieces with your order. It's that simple. No coupons to send in, no waiting, no hassle!

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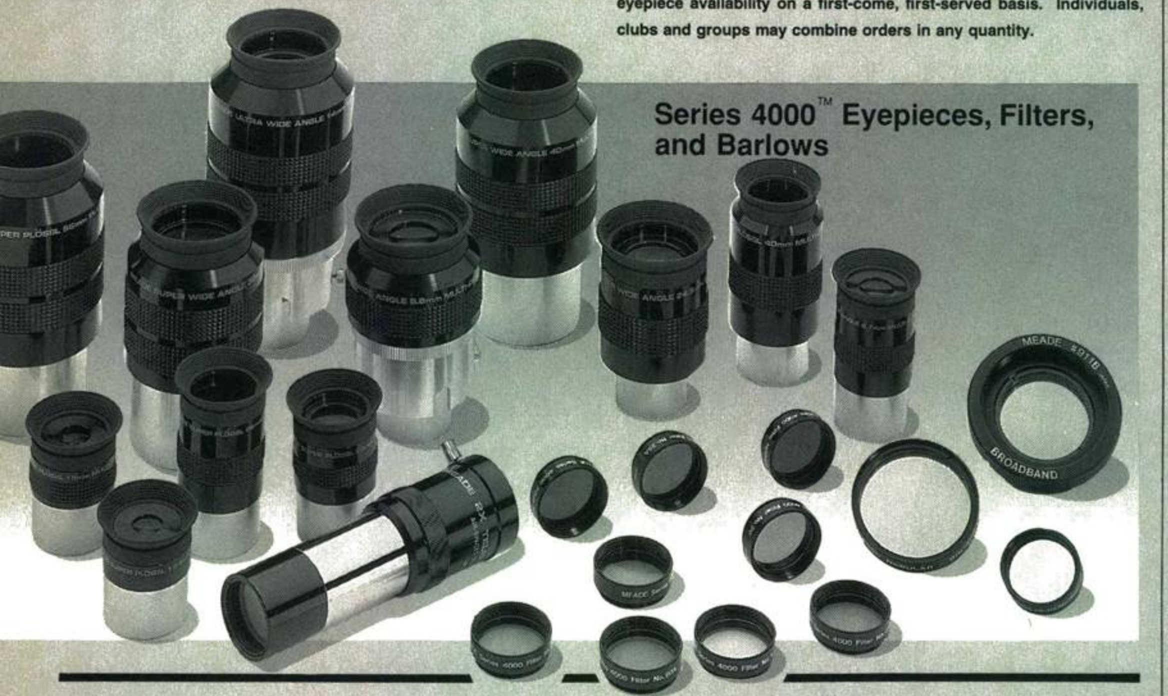

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Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$109.95** (3.29)

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Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Includes wireless red LED illuminator with internal batteries and variable brightness control. **$94.95** (3.29)

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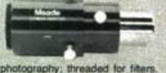
Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": $27.95 (2.79) **1.25": $29.95** (2.79)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-Mount for your camera. **$39.95** (2.79)

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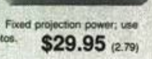

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos. **$29.95** (2.79)

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#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25" **$59.95** (3.29)

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Fine 4-element oculars that yield excellent image quality with any telescope. Computer-optimized design provides wide, flat fields, highly corrected for spherical and chromatic aberrations. Parfocal, multi-coated, 1.25" barrels. Threaded for filters. **Focal Lengths: OR 4, 6, 9, 12.5, 25mm.**

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An improvement on the traditional Kellner design, the 3-element MA gives sharp, faithful, well-corrected images of the Moon, planets, and deep-space. Multi-coated; threaded for filters. 1.25" **Focal Lengths: MA 9, 12, 25, 40mm.**

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The finest focusers in the industry. Meade rack and pinion mechanisms have precise, ultra-smooth action along the entire travel distance. Housings are machined for tight fit of the moving sleeve. All focuser models may be used on tubes of from 4" to 20" diameter; all accept 1.25" eyepieces. Mounting hardware included.

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Viewfinders: 30mm, 50mm, 60mm

#637: 6 x 30mm-Fine, 7° wide-field finder; coated, achromatic lens; crosshair eyepiece, 2-ring bracket with alignment screws. Attaches to tube diameters 6" to 12" **$49.95** (3.29)

#545: 8 x 50mm- *(lower photo)* Wide 5° field; coated achromatic objective; crosshair eyepiece. White tube. Ideal for telescopes of any aperture. See bracket below. **69.95** (4.28)

#544: 8 x 50mm-- Same as #545, but in Meade blue. **69.95** (4.28)

#957: 9 x 60mm--*(top photo)* Collects 44% more light than 50mm; superior for faint objects; bracket below. **99.95** (4.68)

Bracket for 8 x 50mm: Fits Meade and Celestron SCT's, and other tubes from 7" to 20" diameter. **17.95** (2.79)

Bracket for 9 x 60mm: Fits tubes from 7" to 20" diameter. Removable dovetail included. **22.95** (2.79)

Multi-Coated Giant Binoculars

Superb, fully multi-coated 11 x 80mm and 20 x 80mm Giant Binoculars, ideal for wide-field deep-space observing. **Rubber-coated bodies for rugged field use!** BAK-4 prisms yield bright, sharp, high-contrast images. Hard carry case, tripod adapter included.

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Originally developed by Meade Instruments, these convenient diagonals erect the astronomical image, for terrestrial use of astronomical telescopes. Fully coated.

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- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
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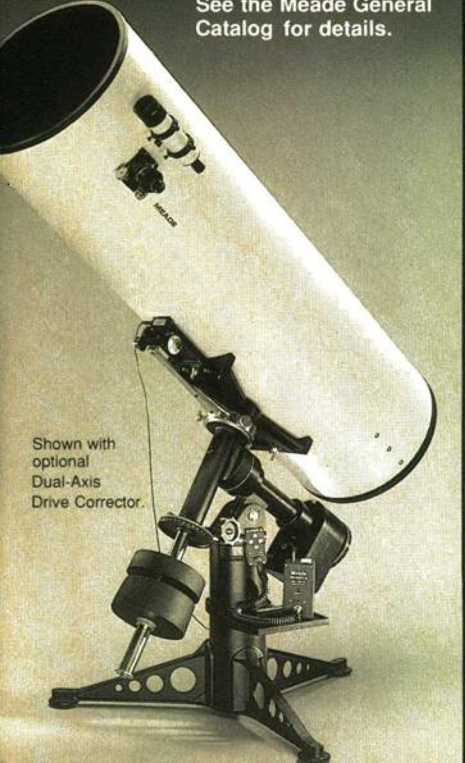

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ADVANCED PRODUCTS DIVISION **Meade Instruments Corporation**

8″ Model 2080A:
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10″ Model 2120A:
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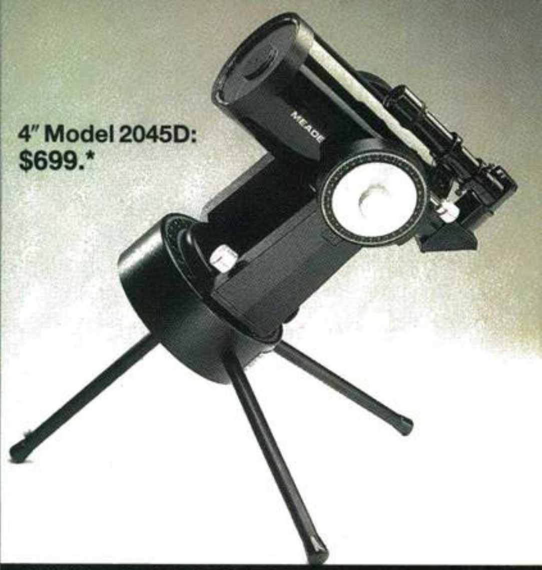

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—O. H. Brettman, Past President, The Astronomical League, Huntley, IL

Meade complete ED Apochromatic Refractors include optical tube assembly with giant 2.7" rack-and-pinion focuser, equatorial mount, field tripod, 8 x 50mm viewfinder, giant 2" diagonal mirror, and Super Plössl 26mm eyepiece:

4" f/9 Model 102ED, complete	**$2195.**
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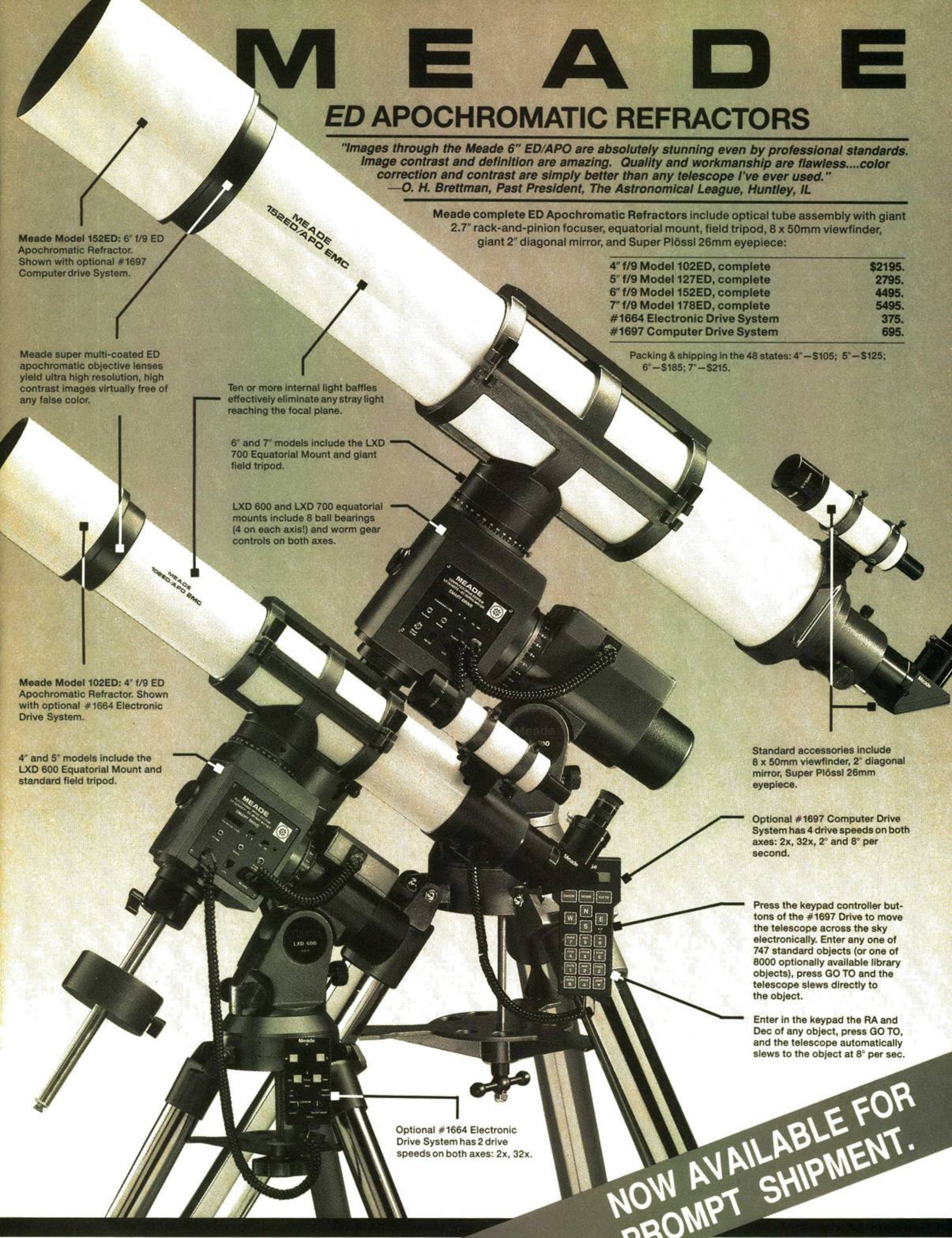
6" f/9 Model 152ED, complete	**4495.**
7" f/9 Model 178ED, complete	**5495.**
#1664 Electronic Drive System	**375.**
#1697 Computer Drive System	**695.**

Packing & shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.



Meade Model 152ED: 6" f/9 ED Apochromatic Refractor. Shown with optional #1697 Computer drive System.

Meade super multi-coated ED apochromatic objective lenses yield ultra high resolution, high contrast images virtually free of any false color.

Ten or more internal light baffles effectively eliminate any stray light reaching the focal plane.

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LXD 600 and LXD 700 equatorial mounts include 8 ball bearings (4 on each axis!) and worm gear controls on both axes.

Meade Model 102ED: 4" f/9 ED Apochromatic Refractor. Shown with optional #1664 Electronic Drive System.

4" and 5" models include the LXD 600 Equatorial Mount and standard field tripod.

Standard accessories include 8 x 50mm viewfinder, 2" diagonal mirror, Super Plössl 26mm eyepiece.

Optional #1697 Computer Drive System has 4 drive speeds on both axes: 2x, 32x, 2° and 8° per second.

Press the keypad controller buttons of the #1697 Drive to move the telescope across the sky electronically. Enter any one of 747 standard objects (or one of 8000 optionally available library objects), press GO TO and the telescope slews directly to the object.

Enter in the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8° per sec.

Optional #1664 Electronic Drive System has 2 drive speeds on both axes: 2x, 32x.

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members. I think both of these paradoxes will be resolved in the next 20 years and their resolution will lead to a fundamental breakthrough in our understanding of galaxy dynamics. — *Jack W. Sulentic, University of Alabama, Tuscaloosa, Alabama*

Equipment for amateur astronomers will be much better 20 years from now. CCDs and other electronic imaging probably will far surpass today's level of sophistication. Adaptive optics could make large aperture diffraction-limited imaging routine for amateurs.

Unfortunately, light pollution will greatly limit astronomy for urban and suburban amateurs. The possibilities for backyard astronomy are exciting. The question is, "Will we still have a sky to enjoy?" —*Kim Zussman, Thousand Oaks, California*

We've been trying to think of any 20-year period in history that might have been more exciting than the coming 20 years should be. The electronic revolution is bringing amateurs computer control over both visual and photographic astronomy at prices that are finally within our reach.

For us, digitizing our negatives is now standard. We are computer enhancing and unsharp masking, and are able to look at detail on screen that we had never seen in our photo prints. We'll be even more astonished when a CCD for high-resolution photography replaces our camera. — *Bill and Sally Fletcher, Malibu, California*

Deep-sky observing will continue to prosper. More amateurs will rely on technology to "observe" as the prices of gadgets decline. Low-end telescopes will increase in quality and the market for junk telescopes will dry up. All of this points toward more serious observing by many motivated amateurs, but basic fun-loving deep-sky observing will continue happily along. — *Alan Goldstein, Louisville, Kentucky*

Increasing light pollution in and around cities will force astronomers to retreat to dark sky preserves during favorable weekends. Such preserves could form the basis for a massive, government-sponsored re-education program to demonstrate the scientific and educational value of the night sky.

Astronomy clubs will benefit from a more tightly knit amateur community. Members will share ideas, experiences, and resources within close geographic distances and will sponsor national conferences devoted to addressing the challenges clubs face. — *Tom Gill, Wauwatosa, Wisconsin*

Historians keep telling us to look to the past for lessons about the future. I'm not sure that works with astronomy. When I was first in the field 35 years ago the universe was much simpler. The many trends and developments that will highlight the coming 20 years will make things even more complicated — and exciting — than they are now.

Clearly the new generation of large telescopes will open new vistas for astronomy. We may find Earth-like planets in our galactic neighborhood and, by implication, expect to find them throughout the universe. We should be able to glimpse "edges" and therefore origins of the universe. What this will tell us about how and why it exists remains to be seen.

Amateurs will increasingly be able to contribute to the science, if they wish. Precision stellar photometry and searches for faint comets, asteroids, novae, and supernovae will play a larger role in the future. But I hope that most amateurs are content with enjoying the night sky and generating images of it they can enjoy in the quiet of their living rooms. — *Klaus Brasch, Highland, California*

Over the next 20 years we'll see an increase in the number of people seeking the eclipse-chasing experience. Total solar eclipses will continue to be one of the strongest areas of amateur interest. In my mind, the ultimate eclipse experience will be, of course, one that deposits the participants on our Moon and shows them a solar eclipse by Earth. My only regret is that probably I won't be alive to take part in a trip like that one. — *Joel K. Harris, Burbank, California*

Correction

The eyepiece diagrams on page 58 of the June issue depict the Tele Vue Wide Field eyepiece as having five lens elements. In fact, all Wide Field models have six lens elements. The negative element that forms the field lens was inadvertently omitted. ☐

ASTRONOMY welcomes suggestions and additional information about articles and astronomy in general. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

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WHERE'S AMATEUR ASTRONOMY GOING?

Anniversary issue? What'll we possibly put into it? One thing that occurred to us here at ASTRONOMY *was to predict what will happen over the coming 20 years in amateur astronomy. After all, the trends over the past several years have shown a powerful and rapid evolution of technology for backyard astronomy.*

So much hallway talk about the future struck our ears over the past few months that we figured it was about time to get some of it down on paper.

Robert Burnham

Robert, the magazine's editor, brings a wide variety of experience to his work, both in science journalism and backyard observing, particularly relating to the Moon and solar system.

Telescopes will still be sized in inches.

Portable equatorial mountings will become sturdier as amateurs demonstrate a demand for them.

Almost every telescope (except the cheapest) will have computer controls or electronic sky-coordinate readouts.

The "virtual observatory" — indoor remote observing — will become easy to do and commonplace. Amateurs will use club observatories from their own houses by computer.

We will frequently see refractors in the 10- to 12-inch range with focal ratios around f/7. We'll also see home observatories to house them.

Big Dobsonians (30-inchers and bigger) will be common and will have fast (f/2 or f/3) focal ratios. Their mirrors will be spun cast. The scopes will be easier to transport than today's models as manufacturers take advantage of lightweight technologies.

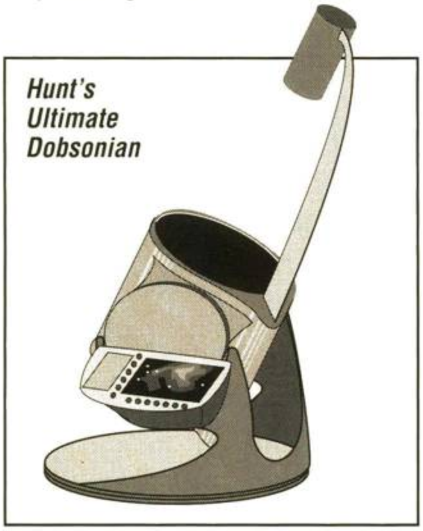
Coma-correcting eyepieces will become standard in all sizes. The 0.965" barrel eyepiece will vanish and be replaced by the 1.25" size on low-cost import telescopes.

All low-cost import telescopes will be designed in Japan or the United States but will be manufactured in places like Thailand, Vietnam, and China. Import scopes will include Dobsonians.

Light pollution will continue to grow for the next decade but then will level off as energy-conservation ordinances become routine for municipalities. Ordinances will cut down on late-night lighting. The sky after local midnight will be darker than it is now.

Planetary viewing will increase in popularity and sophistication. CCD planetary patrols will make routine discoveries of atmospheric events on Mars, Jupiter, Saturn, and Neptune.

We'll still hear people saying "What this hobby needs is a good $250 telescope for beginners."



Hunt's Ultimate Dobsonian

Tom Hunt

Tom creates many of our illustrations but is mainly responsible for the design of the magazine. He supervises the design staff, guides illustrators in creating diagrams, and directs our freelance space artists.

With a typical beginner's scope, amateurs will choose the type of observing they want to do from an electronic menu. The internal GPS (global positioning system) and computer will work together to calculate the position for the given object from the location and time, plot out an observing path, and slew the telescope accordingly. When an object enters the eyepiece, the screen will display pertinent information about it and record information about the observation to create a diary.

The ultimate Dobsonian will contain all of these elements plus a tracking feature to allow photography with these scopes. Viewing will be accomplished with an electronic, real-time imaging screen. Drive wheels on the baseboard and trunnions will enable observers and photographers to take advantage of these big Dobs without constructing a mount that would rival Palomar.

Alan Dyer

With a background in planetarium astronomy, astrophotography, and telescopes, Alan is our resident equipment expert. He also interacts with many clubs and individual amateurs throughout the course of his duties.

Amateur astronomy is more popular now than it was in the '50s and '60s. No longer the domain of the archetypal "science nerd," it now appeals to men and women of all ages and interests. At star parties, which themselves have boomed in popularity since the early '70s, it's now common to see couples and families participating in the hobby together.

In the next 20 years the hobby will expand on all fronts. Telescopes and books now available allow us to pursue any number of areas of interest: observing planets, tracking down deep-sky objects, photographing the night sky, imaging objects electronically, using computers, making telescopes, you name it. The manufacturers have given us an incredible candy store of equipment delights to pick from. It's hard to know where to begin.

No one area or type of equipment will dominate the hobby. Computerized telescopes will thrive alongside no-frills Dobsonians, CCD cameras will complement conventional cameras, observing planets will be just as popular as looking at faint fuzzies.

But the finest equipment and darkest skies alone won't guarantee a bright future for backyard astronomy. Back in 1912 a popular author of the day, Kelvin McKready, wrote in his *Beginner's Star Book,* "I once asked an accomplished watcher of the skies how he had managed to begin and to begin successfully. His reply was 'I had a friend.' There could have been no better answer." To ensure the continued growth of the hobby, we all have to be friends to those getting started in backyard astronomy.

Dave Bruning

Dave is our resident professional astronomer, with an extensive background in solar and stellar physics. Among his specialties are computers and software, and equipment building projects.

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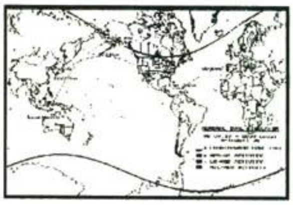

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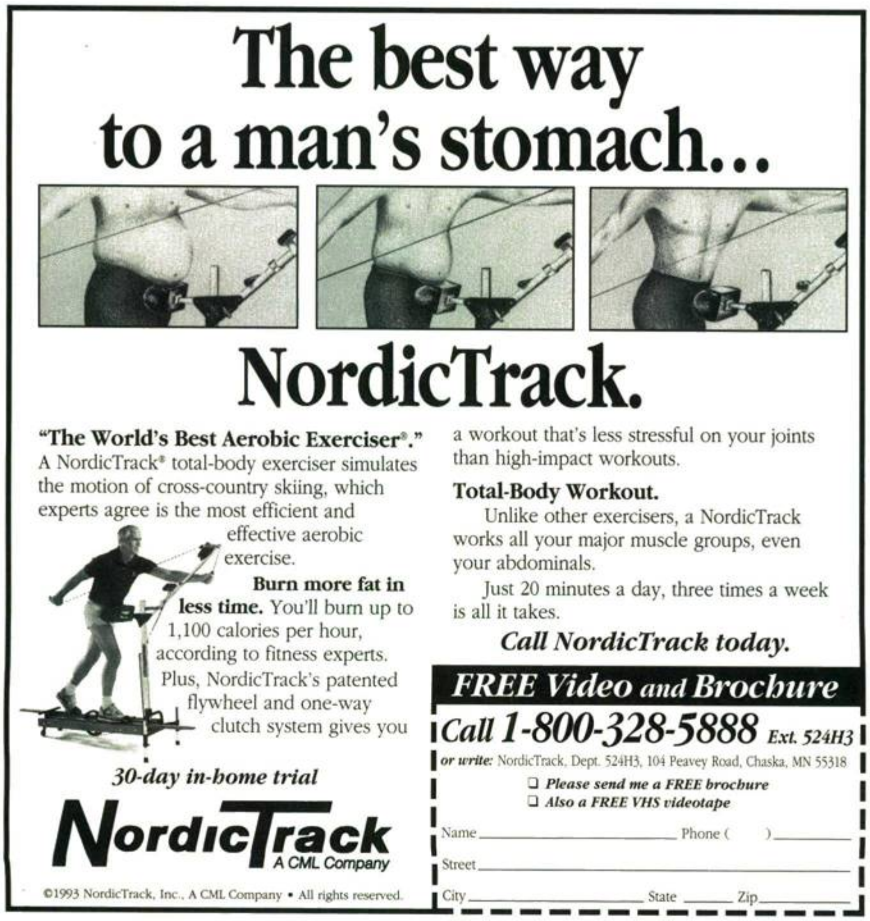

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observing may come from segmented mirrors. Declining costs for the control mechanisms may make such technology available to amateur telescope makers in 10 to 20 years, opening the door to inexpensive, large scopes.

In the next five to ten years, backyard astronomers will start to see big CCD arrays that will take panoramic images. These cameras are going to drive the cost of the smaller cameras down, making CCDs accessible to a larger group of astro-imagers than is presently enjoying their use. CD-ROM technology will also progress so CCD images can be stored automatically on CDs, bypassing the disk storage problem facing many enthusiasts now.

The greatest boon to microcomputer astronomers will be software utilizing CD-ROMs. We're already seeing Mars' maps and image libraries that are fun to explore. CD-ROMs will also open the door to many catalogs of deep-sky objects that have been largely inaccessible to amateurs. CD-ROM drives are already affordable; like disk drives, their price will keep falling, or for the same price you'll be able to buy a faster unit. Of course, the new link to Kodak Photo CDs will help make CD-ROM drives standard equipment on astronomers' computers.

Dave Eicher

Dave's background is in observing with an emphasis on deep-sky objects. He coordinates the news department, keeps watch over reader submissions of photos, images, and observations, and acts as librarian for the staff library.

The information revolution will expand as authors and publishers continue to distribute better quality information and images. Because of this, amateurs will begin to explore a far wider range of deep-sky objects, becoming familiar with thousands of objects now known only to professionals.

Light pollution will be a daunting problem, but will not destroy or even seriously wound backyard observing. We'll begin to see a swing toward energy efficiency, though things will get worse before they improve.

Telescopes will be more sophisticated and contain more electronic gadgetry, which amateurs will love — especially beginners. Scopes will routinely find objects for the user and contain software to enhance electronic images, affording a real-time, image-enhanced, light-pollution-filtered view of deep-sky objects.

CCDs will revolutionize "astrophotog-

[continued on page 16]

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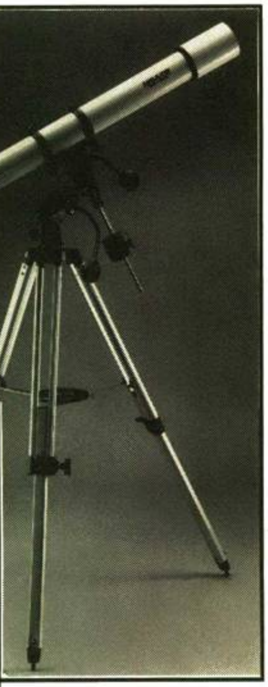

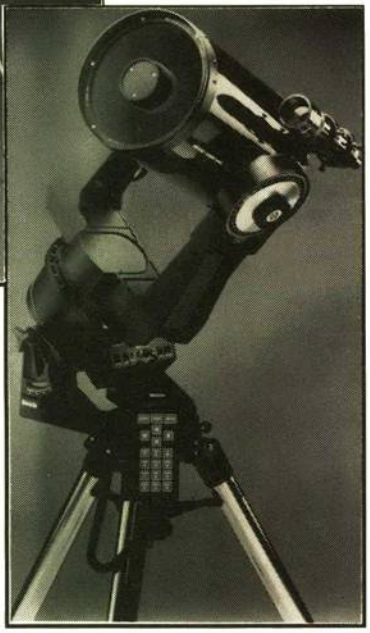

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raphy," which everyone will call "astroimaging" in about five years. This is particularly good news for future pages of ASTRONOMY, which will be more beautiful in the second 20 years than the first.

Driven by inventive minds, curiosity, and technology that affords better data, advanced amateurs will make great strides in areas explored only tentatively in the past: supernova and nova searching, asteroid astrometry and photometry, occultation watching, variable star observing, and the estimating of brightnesses of diffuse objects like comets. Precise digital data will make these projects beneficial to professional astronomers, who will work eagerly with competent amateurs.

Despite the dizzying progress transforming our hobby, most observers of the early 21st century will still want to simply gaze at the sky for relaxation and enjoyment. Technology will transform the capabilities of amateur astronomy but not the desires of the human heart.

Rich Talcott

Rich brings his background in astronomy, mathematics, and computers to many projects, concentrating on observational stories and science features relating to cosmology. He is responsible for much of the Almanac that forms the core department of the magazine.

Most of the changes in amateur astronomy during the next twenty years will be evolutionary, not revolutionary. In equipment, this means we'll see greater numbers of large telescopes. Twenty years ago backyard astronomers considered an 8-inch scope to be big. Eight inches now qualifies as medium aperture, so 20 years from now an 8-inch telescope will be on the small size. But the trend to more large scopes won't be paralleled by a trend toward ever-larger scopes. Few amateurs will ever opt for a telescope more than 30 inches in diameter.

Computer envy will replace aperture envy as more people buy sophisticated computerized telescopes. The marriage of computers to telescopes will accelerate the shift from bulky equatorial mounts toward altazimuth mounts using computers to track celestial objects.

CCD imaging will really take off. Those who never had the patience for astrophotography will have the technical means to produce stunning images. CCDs will be the method of choice for many amateurs, particularly those more interested in obtaining data than in shooting aesthetic pictures. For those intent on capturing beauty, traditional astrophotography will prevail.

Rhoda Sherwood

As Managing Editor, Rhoda supervises the work and workers. That is, she keeps the work flow flowing and our writing graceful. But can one trust the observations of someone who only recently learned the names of the planets?

I suppose that because people change, their approach to the hobby will change. First of all, ASTRONOMY surveys show that a large percentage of hobbyists are Baby Boomers, people in their late 30s to mid-40s. In 20 years you know what that'll mean: people in their late 50s to mid-60s. And you know what that means: facing the eternal verities. Astronomy aficionados already experience a sense of awe under the skies. (Awstronomy?) Put that together with changes taking place in religious/spiritual thinking, particularly in the West, and we might find a blend of spiritual/scientific metaphors in talking and writing about this hobby. Perhaps writers will offer more "think" pieces about our reactions to what we see as well as pieces rooted in science. Perhaps, in fact, someone can use the metaphoric phrase "the face of God" without embarrassment and others can hear it without wincing?

Renewed enthusiasm for the beauty of language may promote the exit of acronyms as speakers strive for subtleties of expression. Staff meetings will no longer include dialogues like . . . (This dialogue brought to you by Dave Eicher. My repression of acronyms has been sublimely successful.)

Dave Eicher: "We've got hot new PICT, FITS, and TIFF files of PKS 72000+160, CGCG 7205, and P-K 206-40.1 and the hub and nuclear detail are terrific."

Alan Dyer: Ya know, pop those babies up on the Supermac in HSB palette display, HAM format, and the nuke and arms'll explode off the screen."

Robert Burnham: "Accessory update: PRONTO, APOs, COMPUSTAR, TELRAD, STARBEAM, TELEPOD, MICROSTAR, and MEGASTAR need reviews."

Dave Bruning: "Not to change the subject, but NASA, JPL, and STScI have announced a data dump from HST, ERBE, IUE, COBE, and EUVE."

Rich Talcott: "W.O.W!"

Tracy Staedter: "Hey, guys, I think I'd like a BLT for lunch."

A curse emanates from the Managing Editor. She slouches and slides floor-ward muttering, "In the end was The Word and the word was PRONTO, STScI, EUVE, HST." □

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YOUNG STAR'S JETS HEAT STRANGE NEBULA

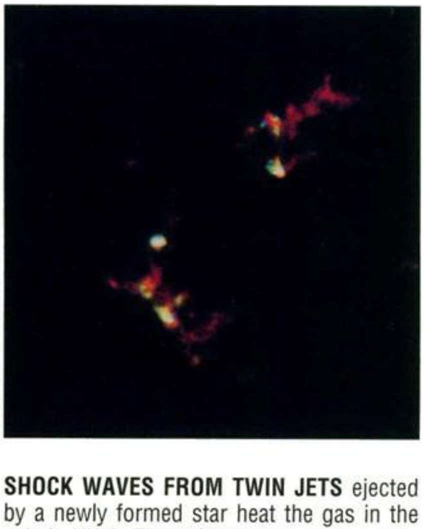
Astronomers using the Hubble Space Telescope have seen the havoc wreaked by high-speed jets of gas shooting from a newly formed star. The jets plow into the cloud of gas and dust surrounding the young star, creating shock waves that heat the cloud to temperatures near 100,000 kelvins.

The observations, made with Hubble's Wide Field/Planetary Camera, zeroed in on the surrounding cloud, which is known as Herbig-Haro object #2 (HH-2). HH-2, the second of several peculiar nebulae discovered in the early 1950s by American astronomer George Herbig and Mexican astronomer Guillermo Haro, lies about 1,500 light-years away in the constellation Orion. The new star itself lies embedded in a dusty cocoon inside HH-2, which hides it from view at optical wavelengths. Thus HH-2 provides the only visible clues to what's going on in the young star.

"The fine detail, never before seen in such objects, provides a challenge to astronomers who are attempting to model the physical processes associated with star formation," says team member Richard Schwartz of the University of Missouri at St. Louis. The images reveal structures as small as a few billion miles across, about the size of our solar system.

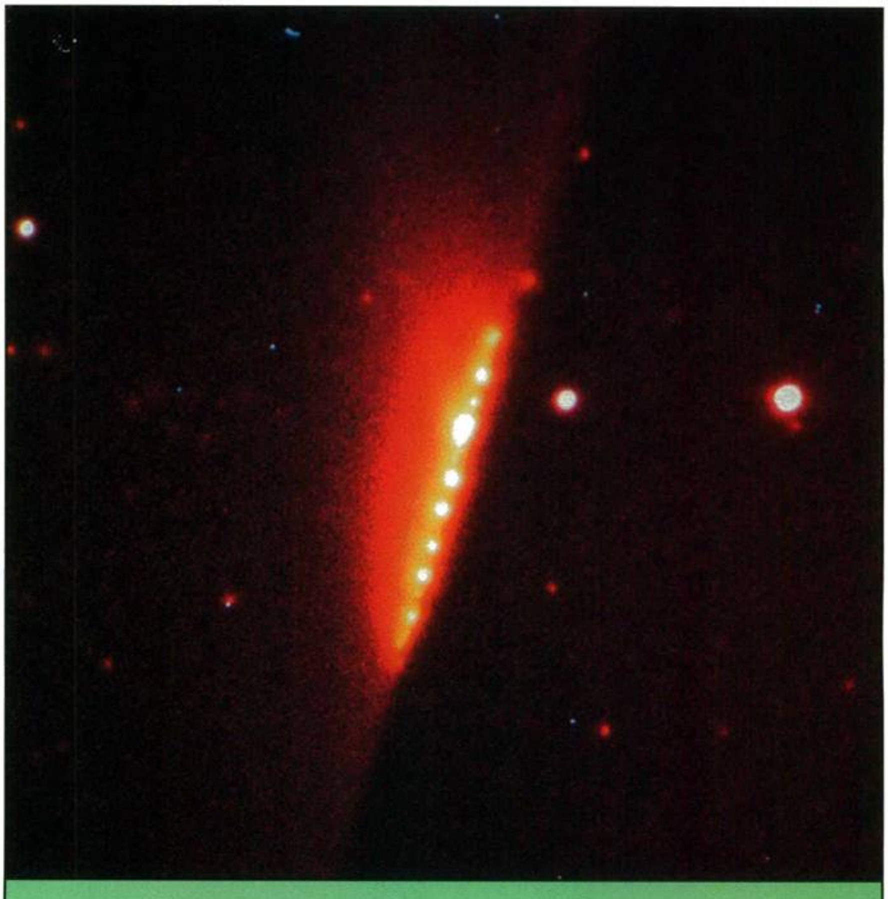
HH-2 has been an enigma to astronomers because of its irregular, somewhat chaotic appearance. The nebula doesn't show the regular, bow-shock structures seen in other Herbig-Haro objects. Such bow-shock structures resemble the wave that emanates from the bow of a boat as it slices through water. Schwartz speculates that the structures seen in HH-2 may result from the fragmentation of a bow-shock by a gas jet coming from the young star.

The high-speed jets that shape HH-2 form as the young star contracts under its own gravitational pull. As it heats up, the star ejects hot gas in the form of a strong stellar wind. However, a thick disk of cool gas and dust left over from the star's formation surrounds the star, forcing the hot gas to squirt out along the system's rotational axis at speeds up to 200 kilometers per second. The supersonic flow in this pair of narrow jets forms shock waves, heating the gas in HH-2 to temperatures around 100,000 kelvins. Though a cocoon of dust obscures the star from view, the effects of the jets can be seen across great distances.



Richard Schwartz and NASA

SHOCK WAVES FROM TWIN JETS ejected by a newly formed star heat the gas in the nebula HH-2. This HST photo combines images taken in the light of ionized oxygen (coded blue), hydrogen (coded green), and sulfur (coded red), with blue representing the hottest gas and red the coolest. The image is approximately 480 billion miles on a side and resolves features as small as 3 billion miles across.



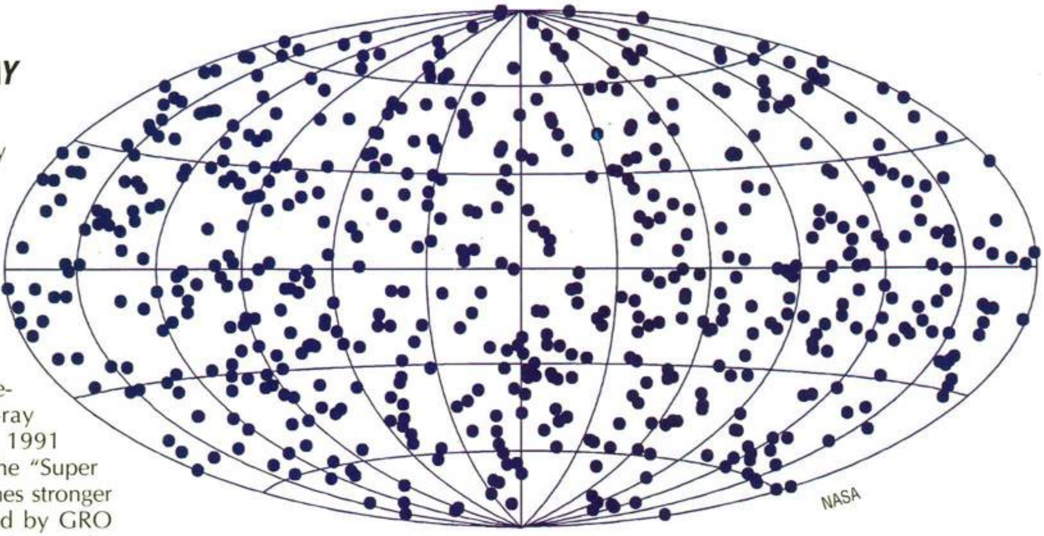
Jane Luu/University of California at Berkeley

A CHAIN OF NUCLEI was visible last spring in Comet Shoemaker-Levy (1993e), one of the oddest comets yet observed. Jane Luu of the University of California at Berkeley imaged the comet with the 2.2-meter telescope at Mauna Kea, Hawaii, on March 27, 1993. The comet's disintegration into at least twenty distinct clumps may have resulted from the gravity of Jupiter, which Shoemaker-Levy passed close to — and now appears to be orbiting — or from a rapidly spinning nucleus that fractured. Either way, the fresh ice recently exposed reflects sunlight efficiently and causes the dazzling appearance of pearls on a string.

BRIGHTEST GAMMA-RAY BURST SEEN

To many people, January 31, 1993, was Super Bowl Sunday — a day to watch the football game between the Dallas Cowboys and Buffalo Bills. But luckily for astronomers, the Compton Gamma Ray Observatory (GRO) spent January 31 watching the sky, where it detected the brightest gamma-ray burst since before the April 1991 launch of the observatory. The "Super Bowl Burst" measured ten times stronger than any previously observed by GRO and hints that gamma-ray bursts may be much more common than previously thought.

Gamma-ray bursts are incredibly brilliant flashes of gamma rays that flare into existence and then disappear in a matter of seconds (see "Bursting with Surprises" by Richard Talcott, March 1992). Based on observations by GRO's Burst and Transient Source Experiment (BATSE) that gamma-ray bursts appear uniformly distributed across the sky, last year astronomers concluded that the bursts most likely originate in the far reaches of the universe. (If the bursts originated close by, GRO would see most of them confined to the disk of our Galaxy. If the bursts came from the Galaxy's halo most would be distributed uniformly, but GRO should also detect faint bursts from nearby galaxies.) Observations of the Super Bowl Burst, combined with BATSE's ongoing catalog of burst positions (now at 591 and counting), seem to confirm this result.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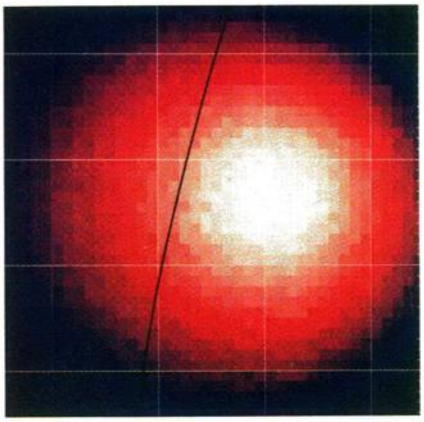
BRILLIANT BURSTS OF GAMMA RAYS come from every direction, strongly indicating that the bursts originate billions of light-years away. The 591 bursts detected by GRO through March 23, 1993, are evenly distributed, with no concentration toward the plane of the Milky Way Galaxy (center horizontal line) or toward its center.

THE POWERFUL "SUPER BOWL BURST" occurred in Virgo, as shown in this false-color EGRET image of the burst's most probable position. The diagonal line shows the position derived from the timing of the burst by GRO and the gamma-ray instrument on the Ulysses spacecraft. Thus the burst most likely originated where this line intersects the brightest portion of the EGRET image.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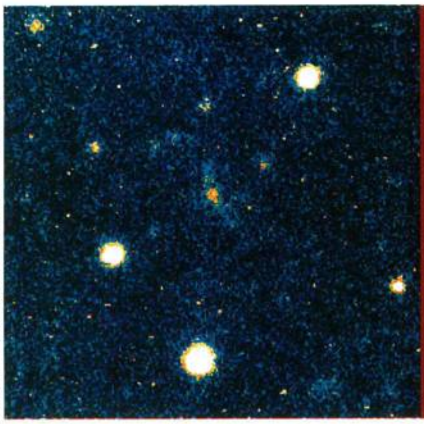
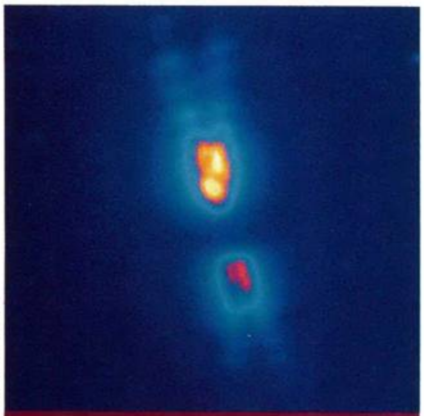
The Super Bowl Burst shone 100 times brighter at its peak than the brightest steady source of gamma rays in the Milky Way Galaxy and 1,000 times brighter than any steady source outside the Galaxy. It was so bright, in fact, that it briefly blinded the BATSE detectors. In most other respects, however, this burst appeared very similar to previous, lesser bursts.

By a stroke of luck, the other instruments on GRO were pointing in the right direction (toward southern Virgo) when the burst occurred. Brenda Dingus, a member of the Energetic Gamma Ray Experiment Telescope (EGRET) team, says that "The EGRET observation of the highest-energy gamma rays suggests they may be emitted in a small beam, like a spotlight, to escape the source. However, to observe such a small beam, it must be pointed at us. So there may be many more objects emitting gamma-ray bursts that we do not see because their beams point elsewhere."


California Association for Research in Astronomy

THE KECK TELESCOPE HAS IMAGED THE MOST DISTANT GALAXY yet known, which lies in the constellation Lynx about 12 billion light-years from us. This near-infrared image reveals detail in the galaxy 4C41.17 and shows what may be several companions surrounding it.

"This was the first attempt to make full use of the capabilities of the 10-meter telescope," said Tom Soifer, a Caltech astronomer who was on the team of astronomers who took the image. "We showed that Keck is as good as we had hoped. No, even better."



Bill Latter/NRAO

THE EGG NEBULA glows in the near-infrared in this false-color image made with the 2.2-meter telescope at Mauna Kea, Hawaii. The object is a bipolar nebula created by an outflow from a central star. William B. Latter of the National Radio Astronomy Observatory in Tucson and three colleagues have studied the Egg Nebula and found a toroidal ring of molecular hydrogen surrounding the object. This suggests a fast and a slow wind produced by the star interact to form the ring.

SPINNING DOWN STARS

Stars forming from a large, slowly rotating gas cloud spin up quickly as the cloud shrinks, much like figure skaters spin faster as they pull in their arms. Newly formed stars may rotate as fast as once per day. But something slows these stars down because astronomers observe that most stars have rotation periods of 10 to 30 days. Suzan Edwards and Patrick Hartigan of the Five College Astronomy Department may have found the secret of how young stars spin down.

Astronomers believe all stars form surrounded by a gas and dust disk. However, Edwards and Hartigan see young stars both with disks and without. Those with disks rotate roughly half as fast as stars of the same age without disks. Presumably the disks have fallen into these latter stars, causing them to spin faster. The stars with disks apparently have strong magnetic fields that help prevent disk material from falling into the stars. Thus the fields prevent the stars from spinning up to rapid rotation rates. Also the stars' magnetic fields combine with the stars' winds (outflow of gas and particles from a star's surface) to spin down the stars as they carry the rotational energy of the stars into space. This new finding will help astronomers better understand how stars evolve during the early stages of their lives.

RADIO WAVES DETECTED FROM M81 SUPERNOVA

Supernova SN 1993J started out as a supergiant star in the spiral galaxy M81. During the million years before the supernova outburst, the supergiant gently ejected material from its outer layers in a brisk stellar wind.

Then came the explosion, which was seen here on Earth in late March after a 10-million-year trip from M81. The explosion formed a jagged shock wave that is racing through space at 6,000 kilometers per second. Where the shock wave catches up with material in the wind, it heats up the gas and generates strong radio emission.

Kurt Weiler of the Naval Research Laboratory and his colleagues used the Very Large Array outside of Socorro, New Mexico, to observe the radio waves coming from SN 1993J. Continued radio observation should help reveal how supernovae mix and heat interstellar gas, promoting star formation.

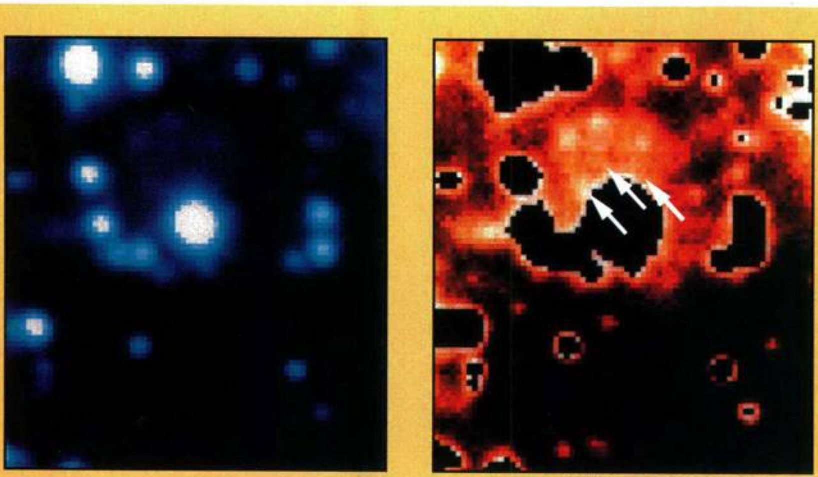
GALAXIES LONG AGO AND FAR AWAY

Giant gas clouds discovered near the edge of the observable universe may be galaxies in formation. The gas clouds, which lie 12 billion light-years away, were first recognized only because they blocked the light from even more distant quasars beyond them. Now Robert Brown and Paul Vanden Bout of the National Radio Astronomy Observatory have used the 12-meter radio telescope at Kitt Peak, Arizona, to observe the clouds shining at millimeter wavelengths and have tentatively identified the clouds as proto-galaxies.

Brown and Vanden Bout observed the clouds at the wavelengths emitted by carbon monoxide molecules. Their observations provided the first estimates of the mass of such clouds and revealed that the objects have enough mass — more than 100 billion times the mass of the Sun — to create galaxies the size of our own Milky Way.

Astronomers believe that galaxies began forming some 10 billion years ago when gas in giant primitive clouds

(continued on page 24)



M.N. Hintzen, E.P. Smith, K.-P. Cheng

THEY'RE BIG, BLUE, AND UNPREDICTABLE. They're luminous blue variables, or "LBVs," and each has a mass of at least 40 of our Suns. Only 32 of these rare stars are known. Joel Parker of the Center for Astrophysics and Space Astronomy in Boulder, Colorado, announced the discovery of the latest bright, blue variable after his research team identified a supergiant star called R143 (the star in the center of the left photo) in the Tarantula Nebula as an LBV. In the last 4 million years R143 has spewed out gas and dust from its unstable surface creating a spoked-wheel nebula that extends up to 11 light-years from the star. In the photo at right the star images have been subtracted to reveal the faint fingers (arrows) created by the stellar winds. Near R143 is supernova 1987A whose progenitor star was probably also a luminous blue variable just before it exploded.

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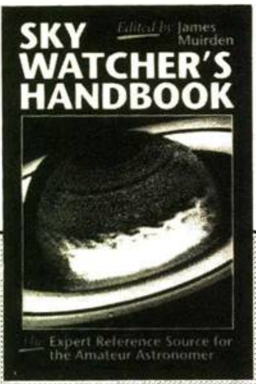

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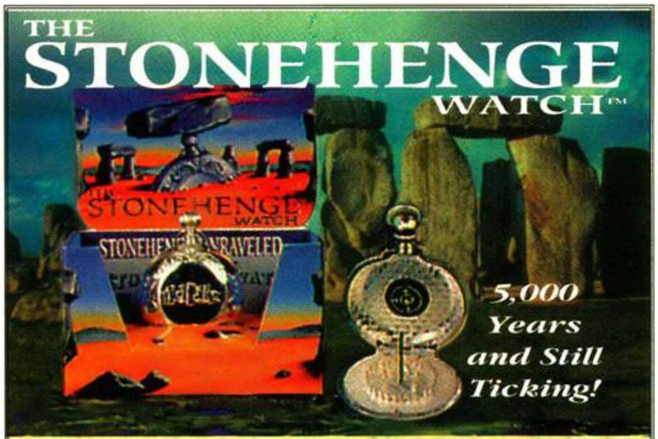

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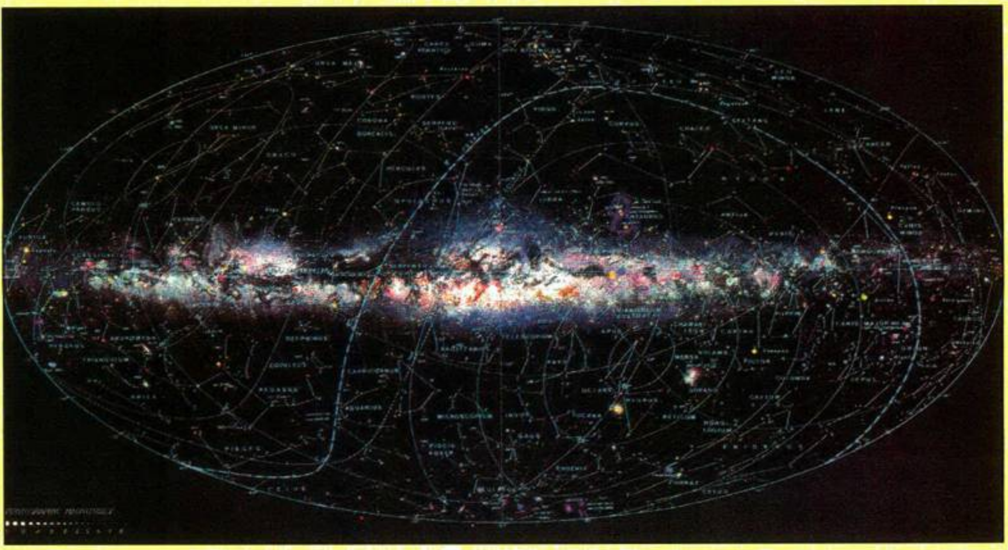

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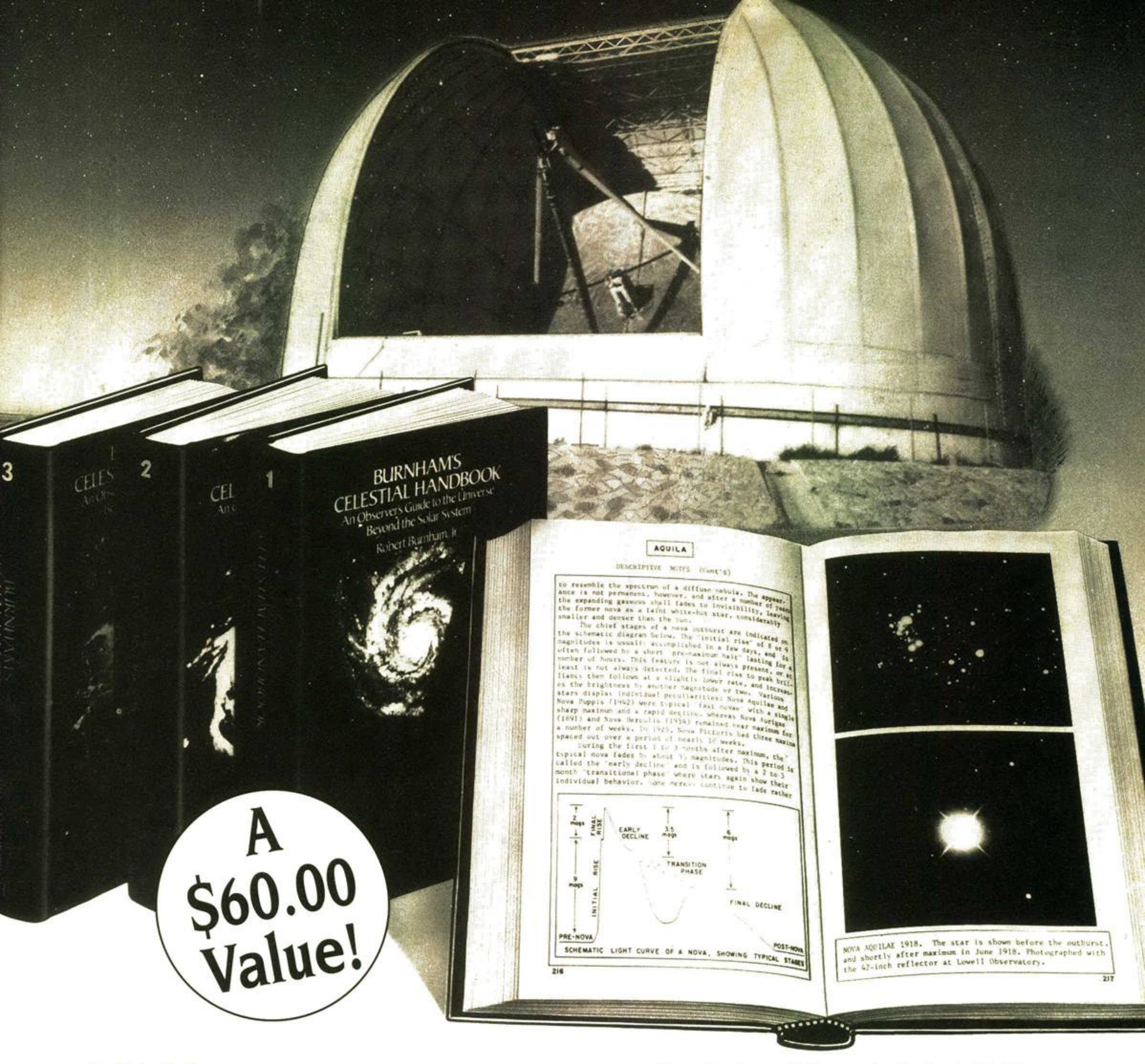
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Astronomy 8/93

started collapsing into stars. The clouds Brown and Vanden Bout observed come from a time before stars began to form. "We see these clouds as they were when the universe was less than 20 percent of its present age," Brown explains.

DIAMONDS IN THE SKY

The discovery last year of microscopic diamonds in interstellar space may lead astronomers to better understand how gas and dust mix in our Galaxy. Diamonds form in shock waves created by red giant stars when they eject material into interstellar space. Louis Allamandola of NASA's Ames Research Center in Moffet Field, California, and his team find the diamonds are common in dense star-forming clouds.

But more surprising was the lack of hydrocarbons (molecules containing hydrogen and carbon) in the dense clouds. In the diffuse interstellar regions they find hydrocarbons that do not exist, but should, in the star-forming regions.

"We thought that the gas and dust in spiral galaxies mixed freely over relatively short periods," Allamandola says.

Scott Sanford, another Ames researcher on the team, explains, "Apparently the hydrocarbons don't survive the transit into dense clouds. This means we don't understand how matter moves in and out of these clouds and that our models of galaxy evolution contain flaws."

Space News

INTERSTELLAR DUST INVADES SOLAR SYSTEM

Astronomers have found the first direct evidence for interstellar dust grains within our solar system. The evidence comes from the Ulysses spacecraft and its February 1992 flyby of Jupiter. (See "Ulysses Meets a Giant," July 1992 and "Motes in the Solar System's Eye," May 1993.) During Ulysses' approach to the planet, the onboard dust detector recorded hits of dust coming from Jupiter. It also detected impacts of micrometer-sized particles moving at high velocity (faster than 26 kilometers per second) in a direction opposite to the orbital motion of the planets. The velocity of these dust grains is well above the speed necessary to escape the solar system. Because the maverick dust particles were streaming in from the same direction that interstellar helium flows past the solar system, the Ulysses scientists have concluded that the particles must have originated between the stars.

The large size of the grains suggests that only the biggest particles are able to penetrate deep into the solar system. Smaller grains may be blocked by the combined barrier of radiation pressure from the Sun and the interstellar magnetic field.

The big question is, what is the dust made of? The answer may come from the Saturn-bound Cassini spacecraft, due for launch in 1997. It will carry a Cosmic Dust Analyser, providing Earthbound astronomers with the identity of the stuff between the stars. — *Peter Bond*

HUBBLE REPAIRS: MORE SPACEWALKS PLANNED

NASA is now planning the long-awaited Hubble Space Telescope repair mission around five spacewalks (or EVAs) instead of the original three, with the possibility of adding a sixth and seventh spacewalk if the first five don't do the trick. "When we looked at accomplishing all of the tasks, highest through lowest priority, five EVAs were deemed appropriate," says Milt Heflin, lead flight director for the mission.

The repair mission, called STS-61, will use the shuttle Endeavour for an 11-day flight in December. Two alternating teams of astronauts will carry out the intensive repairs on Hubble in the payload bay. Priorities include replacing the failed gyroscopes, installing new solar arrays, removing the existing Wide Field/Planetary Camera and installing the new WF/PC II (with its corrective optics) in its place, and then removing the High Speed Photometer and replacing it with COSTAR, the set of optics that will correct Hubble's vision for the three remaining science instruments. See "How We'll Fix Hubble" (February 1993) for more details on the mission.

FROM SPYPLANE TO SKYPLANE

NASA

THE BLACKBIRD'S ONCE-SECRET CAPABILITIES for flying high and fast are now being exploited by astronomers for studying the ultraviolet universe.

The legendary SR-71 spyplane is now being used to study the stars. Since being decommissioned as a reconnaissance plane, the SR-71 (also known as the Blackbird) has become available for civilian tasks. NASA has converted one of its three Blackbirds into a high-altitude observatory. During its maiden flight as an observatory, the aircraft flew at three times the speed of sound at an altitude of 83,000 feet, placing it above much of Earth's atmosphere. The nose bay of the plane carried an ultraviolet video camera for studying the light from stars and comets that cannot penetrate the atmosphere. NASA's fleet of Blackbirds will also be used for aeronautical engineering tests and studies of Earth's upper atmosphere and meteoric dust.

READER'S EXCHANGE

WANTED — Spitz Sky Zoo Projector manufactured by Harmonic Reed Co. in the 1950s. Contact Stephen Pielock, Sand Gully Road, So. Deerfield, MA 01373. Phone (413) 772-6715.

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FOR SALE — Celestron 3.1" f/11 alt-azimuth refractor, 6x30 finder; 1.25" Amici prism, 18mm Orthoscopic eyepiece, adjustable wooden tripod with accessory tray, RA & Dec cables, MCOG, mint. $400. Contact Daniel Rhone, 209 N. Harrison Avenue, Beverly, NJ 08010-2119. Phone (609) 387-4469.

WANTED — Showcase kit to make a balsa- or display-wood model of the 200" scope at Palomar Mountain. Also interested in building a small non-working display (kit) of any observatory's telescope. Contact Alan D. Simpson, 4 Bruns Road, Ansonia, CT 06401.

FOR SALE — Questar items. Piggyback camera mount for 3.5". $115. Late-model 32mm and 16mm eyepieces in excellent condition. $75/each. Prices include U.S. shipping. Contact Frank Calloway, 1100 North Taft Avenue #44, Loveland, CO 80537. Phone (303) 663-1738 evenings.

WANTED — Indian-based astronomer seeks correspondence worldwide with women and men interested in observational astronomy. Contact Sudhakar Bhalerad "Sudhanshu" Bhabha Nagar, New Bombay Agra Road, Nashik 422 011 India.

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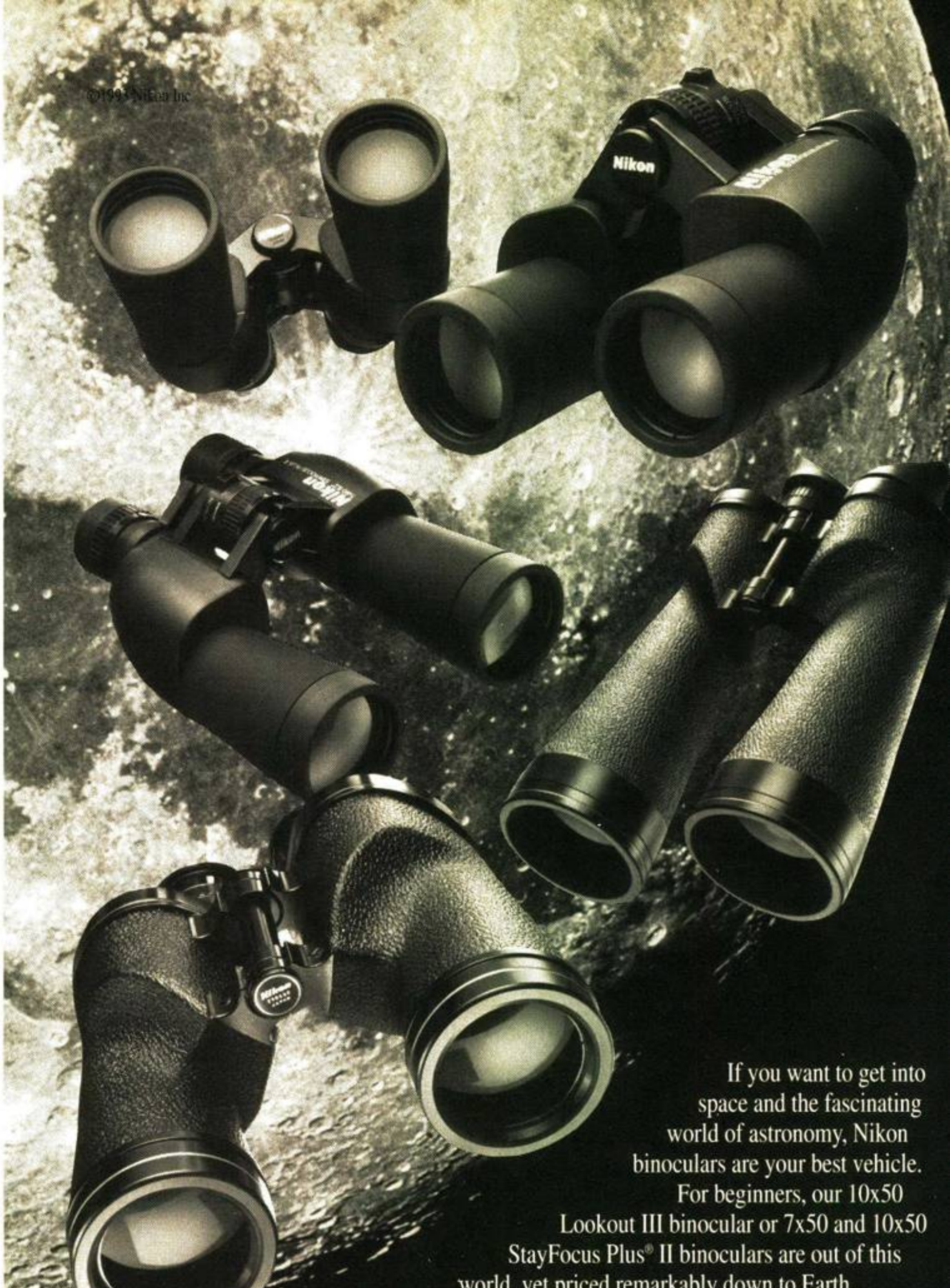
WANTED — Thirty-two-year-old male interested in astronomy and other sciences wishes to correspond with others worldwide. Contact David Bittoge, 117 Nahma, Clawson, MI 48017.

ANNOUNCEMENT — For information about radio astronomy contact Vincent Caracci, Society of Amateur Radio Astronomers, 247 N. Linden Street, Massapequa, NY 11758.

(continued on page 125)



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DOES PROXIMA CENTAURI HAVE A FAMILY?

Look in almost any astronomy textbook and you'll find Proxima Centauri listed as the closest star to the Sun. And usually in the same paragraph, you'll read that Proxima belongs to a triple star system along with Alpha Centauri A and B. Now a pair of British researchers has cast doubt on that second statement.

Amateur astronomer Robert Matthews and Gerard Gilmore of the Institute of Astronomy at Cambridge University report in the March 15, 1993 issue of the *Monthly Notices* of the Royal Astronomical Society that Proxima's motion through space is not known well enough to prove that the star belongs to the Alpha Centauri system. Proxima lies 4.22 light-years away compared with 4.35 light-years for Alpha. This small separation and the stars' similar motions across the sky gave rise to the idea that a physical link existed between Alpha and Proxima. If this is true, Proxima must take a million years to complete a single orbit that extends more than 13,000 astronomical units from the close pair of Alpha A and B.

Matthews calculated that Proxima could only be in orbit around Alpha if the stars' velocities through space were within one percent of each other's. And some velocity measurements show this may not be so — Proxima seems to be moving too fast for Alpha's gravitational pull to keep it in orbit. But precisely measuring the stars' velocities is not easy, so it will take more time — and more accurate observations — to settle the case. ☐

Amateur News

ANTIQUE TELESCOPE SOCIETY HOSTS FIRST CONVENTION

It was standing room only under the dome of the 26-inch Clark refractor. The occasion was the first annual meeting of the newly formed Antique Telescope Society. The meeting of classic telescope collectors took place October 16 to 18 at the U. S. Naval Observatory in Washington, D.C.

Convention-goers admired a display of over 40 antique telescopes and hand-held spyglasses dating as far back as 1700. The telescopes, brought by convention participants, were all beautifully restored instruments from legendary manufacturers such as Dolland, Fitz, Clark, Brashear, Adams, Browning, Mogey, Zeiss, and Bardou.

In addition to the exhibit, the program included talks from Deborah Jean Warner, author of *Artist in Optics* and Curator of Physical Science at the National Museum of American History, and from refractor historian Eugene Rudd of the University of Nebraska.

The next gathering of antique telescope enthusiasts is scheduled for October 22 to 24 at the historic Yerkes Observatory in Williams Bay, Wisconsin, home of the largest refractor in the world, the great 40-inch. For more information about the Antique Telescope Society and the upcoming convention, contact Walt Breyer, 30 Green Valley Road, Wallingford, PA 19086. — *Bart Fried*

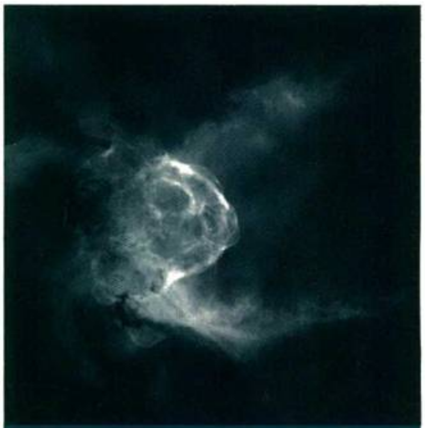
GEORGE LOVI: MAPPER OF THE STARS

If you use a popular star chart such as *Sky Atlas 2000.0* or *Uranometria 2000.0*, you are using a work created in part by George Lovi. On February 18, 1993, George Lovi died of cancer at the age of 53.

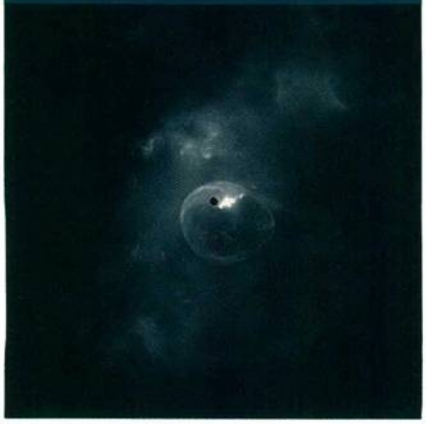
George Lovi was born in Hungary in 1939. He came to the United States as a young boy and lived with his family in Brooklyn, New York, and Lakewood, New Jersey. From 1969 until his death he wrote a monthly column for *Sky & Telescope* magazine called Rambling Through the Skies. This column, which featured sky maps George drafted, made his name famous among amateur astronomers around the world. Over the 24 years George authored the column, Ramblings brought him great popularity. George wrote on all aspects of astronomy, but he was an expert on the history of sky-mapping and celestial cartography, or "uranography" as it is called.

I came to know George when we worked together on *Sky Atlas 2000.0*. I did the charts while George wrote the introduction. George was always one of the most enthusiastic promoters of my work, and was always ready to provide valuable advice and criticism. George was the author of the book *Men, Monsters and the Modern Universe*, a history of star charts and constellation patterns. George also worked as an independent scholar and as an instructor at the Hayden Planetarium in New York.

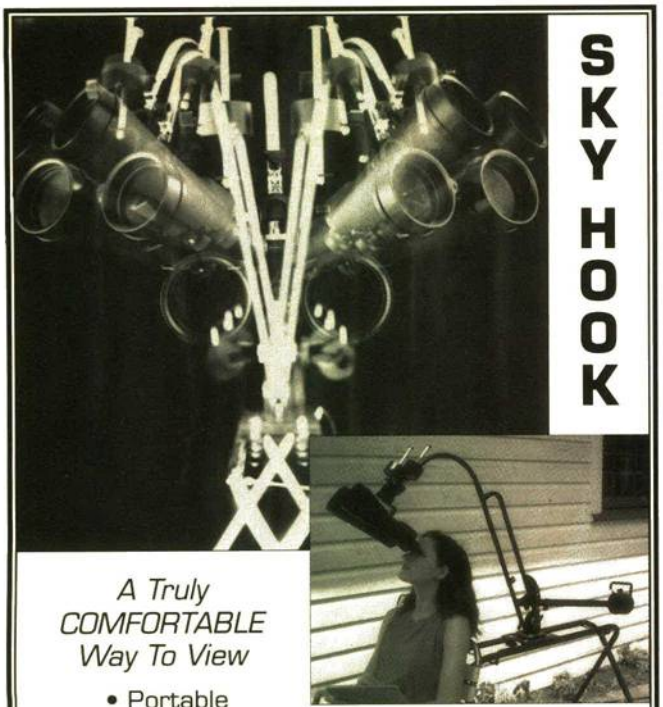
In producing *Uranometria 2000.0*, fellow co-authors Barry Rappaport and I owe George a lot. He contributed to the atlas by writing a detailed chapter on the history of star charts. George once called me an "astronomical and uranographical aficionado," but I believe these words apply to no one better than himself. — *Wil Tirion*



COSMIC BUBBLES GLOW in spectacular detail in these hydrogen-alpha images. The nebula NGC 2359 in Canis Major consists of a bubble blown by a hot Wolf-Rayet star on the edge of a dense molecular cloud (above). The Bubble Nebula (NGC 7635) in Cassiopeia is a bubble being blown by a young, hot O star near a molecular cloud (below). The bright cloud inside the bubble is a dense clump of gas evaporating into the bubble's interior due to the star's strong ionizing radiation.



Reginald Dufour, Rice University; courtesy Dave Van Buren



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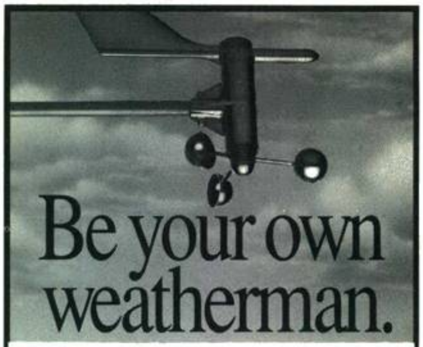

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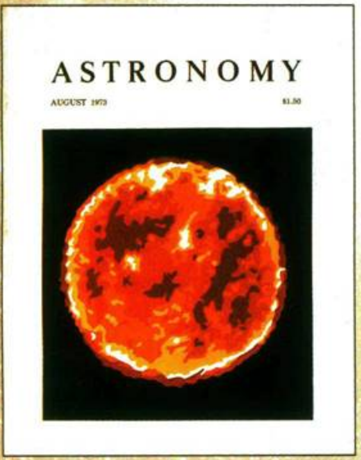
Twenty years ago Stephen Walther founded this magazine on the dream of portraying "worlds unseen." From its inception, ASTRONOMY has sought to bring you the mystery, beauty, and wonder of the universe. The staff and I are proud to continue steering its course.

For this, our 20th anniversary issue, we thought it would be fun to get some of today's top astronomers to go way out on a limb and tell you what they think astronomy will find out in the *next* 20 years. Among those we asked were Carl Sagan, Alan Stern, Carolyn Porco, and Rick Binzel. Associate editor Dave Eicher wove their replies into the feature that starts on the next page. We think you'll get a kick out of their speculations.



August 1973

Next, Michael Carroll takes a look at Discovery, NASA's new low-cost plan for exploring the solar system. Can quality missions come from a sharply pared-down budget? At the conference where NASA began to sift through exciting Discovery mission proposals, Mike spoke to many of the would-be project scientists. In their opinion, he says, today's fiscal realities mean that Discovery offers the only chance for exciting new missions to the Moon and planets.

In "Big Scopes" Robert Bunge takes you behind the scenes and into the high-tech workshops where a new generation of large telescopes is under construction. These instruments dwarf the famed 200-inch on Palomar Mountain. Not even counting the newly completed 10-meter Keck telescope on Hawaii's Mauna Kea, a dozen new giant reflectors will soon be open to the skies, including a twin of the Keck scope itself. These huge telescopes promise to achieve what the astronomers predict.

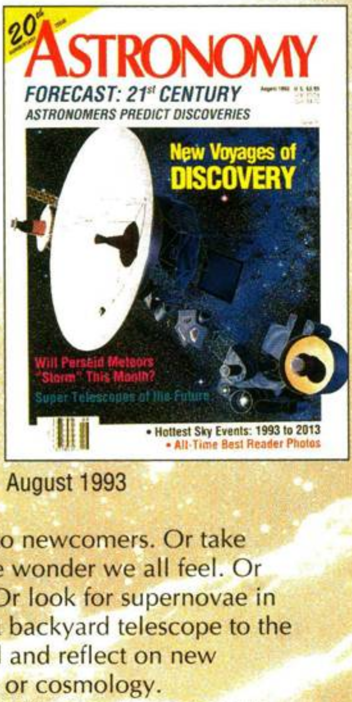
In the second half of the issue, you'll find a big Reader Reports pictorial that highlights the great photos we've received from you over the years. *(And if you think it was easy to narrow the choice to just these, let me tell you...!)* We also preview the outstanding celestial events coming your way over the next 20 years. More traditional observing features in this issue include the fine sights of the summer Milky Way, asteroids Pallas and Vesta, and of course the famous Perseid meteors.

In fact, the Perseids could be downright spectacular this month because their parent object, Comet Swift-Tuttle, returned to our vicinity late last year. If we should see a Perseid "storm," it'll likely be something remembered and talked about for years and years. Don't miss it!

When you look back over ASTRONOMY's two decades, what seems remarkable, at least to me, is the variety of subjects it has covered. I think this simply reflects the wide interests that ASTRONOMY readers have. Some are highly focused specialists, others are determined to keep their perspectives broad. But whatever your particular interests are, you and your fellow readers share a commitment to exploring the heavens. The common thread uniting us all is a love for the intellectual vistas that astronomy opens, as well as the sheer visual splendor it contains.

I also think amateur astronomy today has become a far richer experience than it was 20 years ago. The equipment is better and it's more sophisticated. In addition, more people are engaged in the hobby and they pursue a wider variety of activities. Back then, budding backyard astronomers were usually steered toward doing "useful work," which meant things like timing transits of Jupiter's Great Red Spot or estimating variable star brightnesses. These continue to be highly enjoyable and worthwhile ways to explore astronomy, but loving the heavens doesn't have to begin or end in collecting data.

In a quiet rebellion against such structured approaches, backyard astronomers began to explore different ways of doing astronomy. Steve Walther, part of that movement, created a magazine to serve it. His theme was simple yet radical: There is no one true way to make astronomy meaningful to everyone. Each of us has to find our own way. We may stand outside and appreciate the silent beauty of a deep, starlit sky. Or we may explore constellation lore and teach the timeless patterns to newcomers. Or take pictures that convey some of the wonder we all feel. Or patrol for dust storms on Mars. Or look for supernovae in distant galaxies. We may push a backyard telescope to the limits of its resolution — or read and reflect on new discoveries in planetary science or cosmology.


20th
ASTRONOMY
FORECAST: 21st CENTURY
ASTRONOMERS PREDICT DISCOVERIES
New Voyages of DISCOVERY
Will Perseid Meteors "Storm" This Month?
Super Telescopes of the Future
• Hottest Sky Events: 1993 to 2013
• All-Time Best Reader Photos

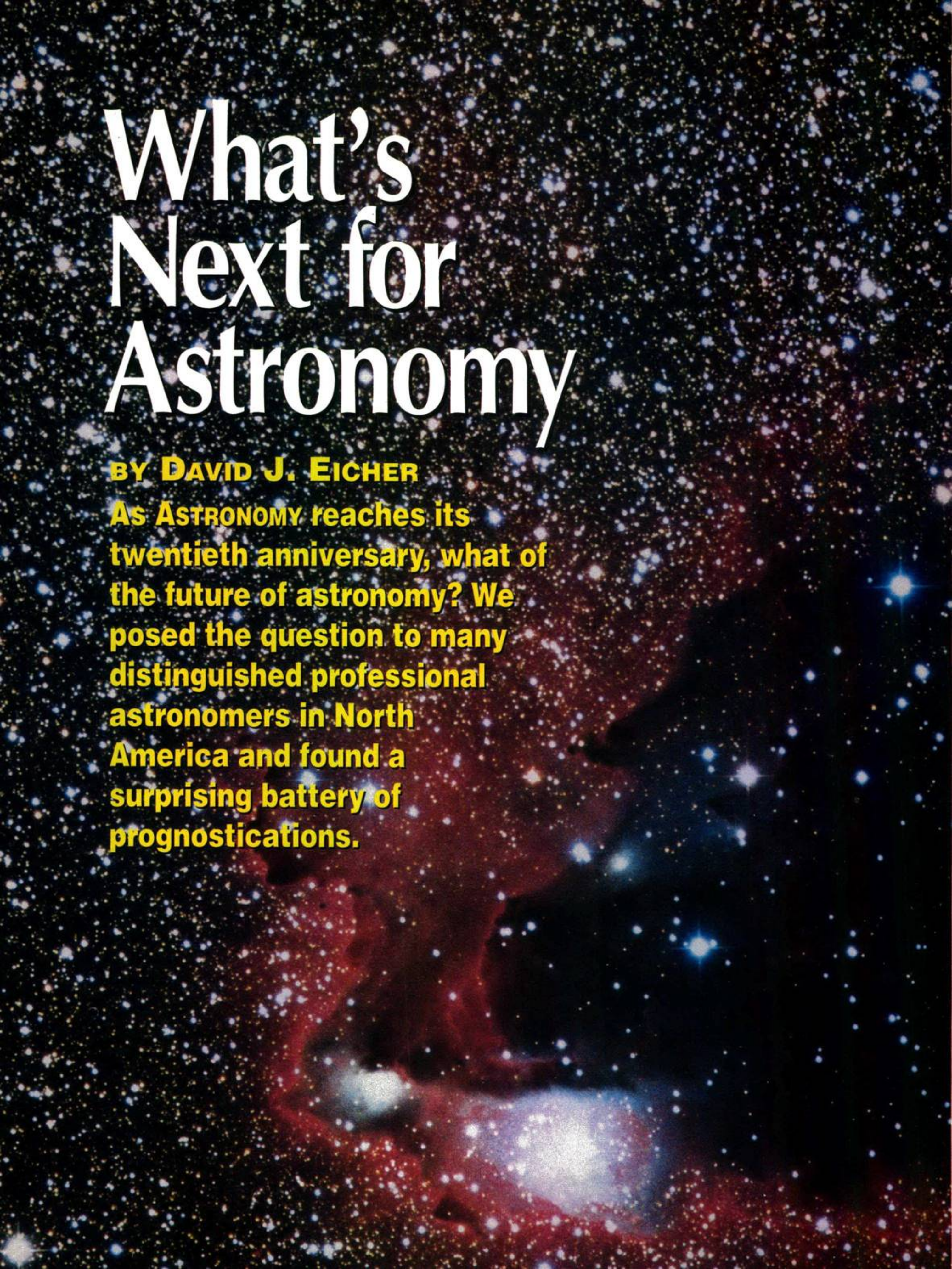
August 1993

The path each of us chooses isn't important except to us personally. What matters is that the dark night sky and the things it contains are beautiful beyond measure. As this magazine enters upon its third decade, you and the rest of ASTRONOMY's readers are all participants in the grandest adventure in the universe.

Sincerely,

Robert Burnham
Editor

Adolf Schaller



What's Next for Astronomy

BY DAVID J. EICHER

As ASTRONOMY reaches its twentieth anniversary, what of the future of astronomy? We posed the question to many distinguished professional astronomers in North America and found a surprising battery of prognostications.

Anglo-Australian Telescope Board

What would you most like to see accomplished in astronomy in your lifetime? The question rang out at the American Astronomical Society meeting in Phoenix last January, in the question period after the Annenberg Prize Lecture given by astronomer Carl Sagan of Cornell University. Sagan's response: "First, I'd like to know if the universe is open or closed. Second, I would like to see a detailed listing of the orbital and chemical properties of the nearest 100 planetary systems. Third, I'd like it if we got an absolutely bonafide, compelling, unambiguous communication from another intelligent species. If we could do just those three," Sagan quipped, "I would be a very happy astronomer."

Cosmologist David Schramm of the University of Chicago typified the astronomers' somewhat wary attitudes about going out on a limb with their predictions. "There's a long track record of scientists completely blowing it," he says. "In 1893 Albert Michelson proclaimed that the study of physics was essentially over, that the only real interest that remained was 'in the fifth place of decimals.' Lord Rutherford noted in 1931 that nuclear energy would never have any real effects on life on Earth."

"Is this fair?" asked stellar astronomer Bruce Carney of the University of North Carolina at Chapel Hill, "asking for a prediction long enough for the crystal ball to be optically thick yet short enough that I'll still be working and thus likely be embarrassed by my twenty-year prognostication?" Thirty-two scientists lay it on the line here. We hope you enjoy our experts' look ahead and invite you to read ASTRONOMY through at least 2013 to see if, by our 40th anniversary, the predictions have come true.

"Science today is under attack."
— Bill Hartmann

One of the most significant challenges for astronomers is to bring astronomy to the public.

"Science today is under attack," says planetary scientist William K. Hartmann of the Planetary Science Institute in Tucson. Newspapers carry astrology columns but not science columns, television science reporting focuses almost exclusively on medicine and technology, and many teachers, parents, and institutions like churches discourage a scientific attitude of skepticism, especially in children — while everyone happily enjoys the fruit of scientific research, he adds.

"During the last month I encountered a gas company bill, a religious newspaper, and a quote from a retired U. S. general all claiming that the greenhouse effect and ozone depletion are frauds," says Hartmann. "How could these people explain the 900° F temperatures on carbon-dioxide-rich Venus? Astronomy's future will not depend on astronomers' dreams," Hartmann contends, "but on the education of citizens throughout our society who must come to grips with science as a rational understanding of the universe and how it works."

The lack of public education means relatively limited public support, too. "The major challenge for astronomy in the next 20 years will be an economic one," says galactic astronomer Frank Bash, director of McDonald Observatory in Texas. "In the context of the end of the Cold War, declining budgets, increasing deficits, and growing social problems, the justification for funding even basic research is being questioned. How much astronomy do we need? How much can we afford? How much can we justify supporting astronomy with public funds? Does astronomical research produce any economic benefit to society? These are serious questions we need to consider."

No one is suggesting eliminating public support for astronomical research, Bash contends, but if astronomers are to move ahead successfully in the coming years, "we must justify the extra support we have above the base level of artists and philosophers."

"In 2013 astronomy will still be asking questions that make us turn inward and outward at the same time."

— Alan Stern

Others see a brighter future for public awareness of astronomy and science, sparked by the pure excitement of our future knowledge of the cosmos.

"In 2013 few people will remember a time before space astronomy," says planetary researcher Alan Stern of the Southwest Research Institute in San Antonio. "By this time we should have a clear answer from SETI: Either we are alone in our local galactic meadow, or we are not, or we are the only ones generating microwaves. We should have in hand a good census of planetary systems near the Sun."

"We will see an increasing emphasis on the formation and evolution of astrophysical systems," remarks galaxy specialist Jay Gallagher of the University of Wisconsin at Madison. "Astronomers will thus be working on origins — of large-scale structure, galaxies, stars, and planets. And maybe even the astronomical context for the beginnings of life."

"We will likely know if gamma-ray bursts are local or cosmological," says Stern. "And we should know Pluto and its moon Charon then as well as we know Neptune's Triton today. We should know whether the Hubble constant is 50 or 90, and whether there really is a Kuiper disk.

"We will be building facilities and space missions not even imagined today. Children will be growing up at the dawn of the new century filled with the same fire of interest and wonder at the glory of nature that we all felt in the middle of the last century. This new era will see kids whose careers in science will stretch over the 21st century, and who can motivate others long into the 22nd century.

"In 2013 the Sun will still be rising, the Earth will still be turning, and astronomy will still be asking questions that make us turn inward and outward at the same time."

"Let's hope that astronomy will come to better reflect the full character of our society."

— Chris Chyba

One of the greatest changes will occur within the field of astronomy itself, some astronomers feel.

"We will see the passage of large numbers of highly competent women astronomers, now in the earliest stages of their careers, into senior positions in the field," asserts planetary astronomer Christopher F. Chyba of NASA's Goddard Space Flight Center. "Currently women comprise fewer than 10 percent of astronomers over 40 years of age but nearly 30 percent of astronomers younger than 30."

A recent survey by Peter Boyce, executive director of the American Astronomical Society, shows that up through age 45 the same percentages of men and women are earning tenure. (There are so few women astronomers over 45 that it makes the statistics for that age class difficult to interpret.) So we can hope that as the larger numbers of young women astronomers mature, their presence will be fairly represented among tenured faculty.

Says Chyba: "Let's hope this means that over the next two decades astronomy, at least in the United States, will come to better reflect the full character of our society. I am proud to be a member of the generation witnessing this transition."

Astronomy educator Andrew Fraknoi of Foothill College and the Astronomical Society of the Pacific sees some hope for the future, too. "Educational change is in the air. Wouldn't it be wonderful if every teacher were required to take a full complement of science classes, including astronomy, in college? And following recent experiments by NASA, government funding agencies might add a 5 percent increment to research grants to help fund the dissemination of research results to the public and the schools."

Extragalactic researcher Yervant Terzian of Cornell University agrees: "I hope that by 2013 every high school in the U. S. will have an operating telescope. If that were the case, the public would be much more aware of our cosmic history, our planetary system, and our place in the universe. I also hope that every researcher will be required to share his or her results in an understandable manner to the public and to fellow scientists."

"We are now at the start of a mini-revolution in ground-based astronomy."

— George Djorgovski

We will need a new generation of telescopes and technology to make the discoveries that will answer astronomy's "big questions."

"The Hubble Space Telescope, the Keck telescopes, and other new telescopes, as well as electronic developments like larger CCDs and higher-resolution infrared arrays, will bring results that will profoundly affect our view of the universe," says solar physicist Jay Pasachoff of Williams College in Massachusetts.

"Son of HST, a space-based 8-meter telescope, will be launched in time for ASTRONOMY's 40th anniversary," says cosmologist John Huchra of the Center for Astrophysics in Cambridge, Massachusetts.

"We are now at the start of a mini-revolution in ground-based astronomy," declares galaxy specialist George Djorgovski of the California Institute of Technology in Pasadena. "Astronomy is replacing particle physics as the new frontier."

Chyba agrees: "By the late 1990s we'll see the implementation of nearly a dozen new large or arrayed optical telescopes, made possible through advances in manufacturing and computer technology. In the decade following 2001, these telescopes will be augmented as adaptive optics become commonplace. No doubt we will see new scientific discoveries now lurking just beneath our current levels of sensitivity and resolution."

"We will get a much clearer, less noisy picture of the universe."
— Sidney van den Bergh

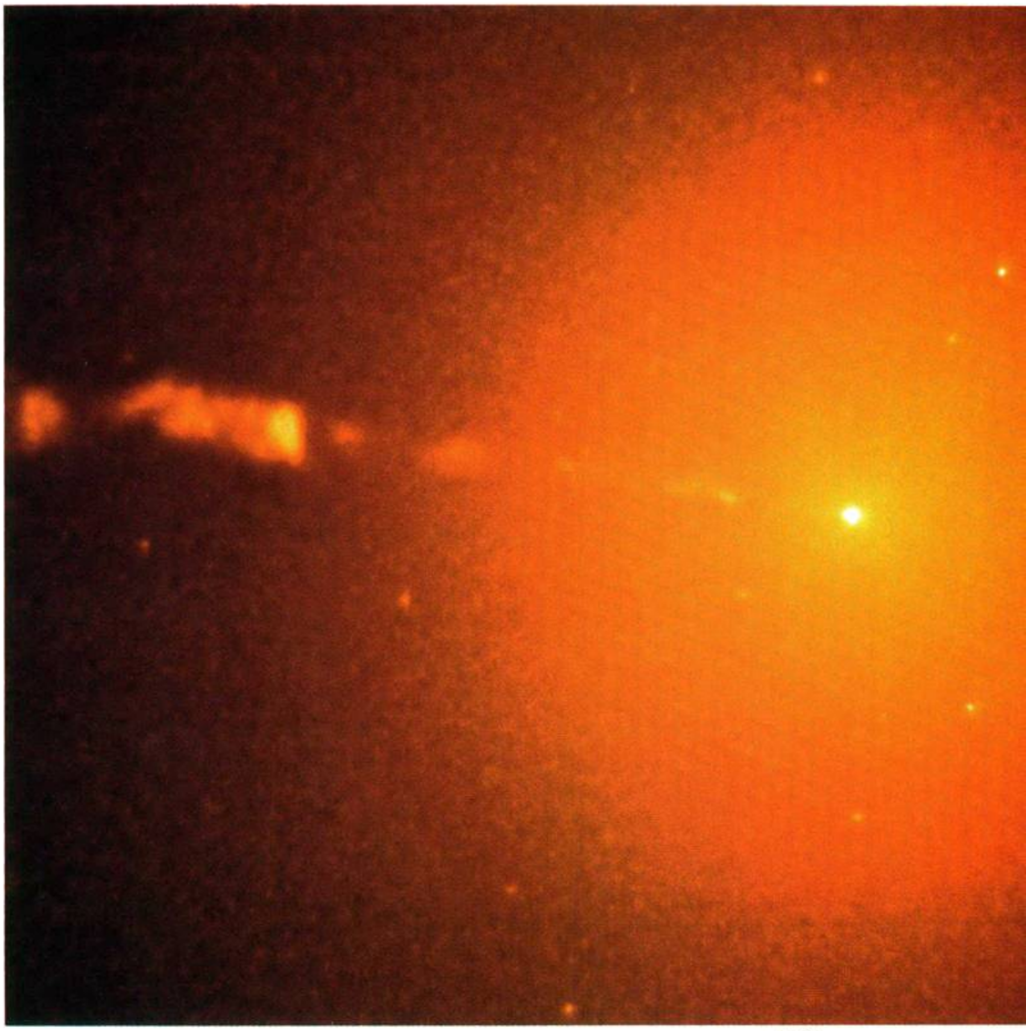
The technological change will be immense, according to galactic astronomer Kevin Krisciunas of the Joint Astronomy Centre in Hilo, Hawaii.

"Half a dozen 8-meter class telescopes will operate on the world's mountaintops," he says. "A flotilla of satellites will orbit Earth, measuring stars, nebulae, and galaxies at all the wavelengths inaccessible from the ground. Automatic photoelectric telescopes will operate routinely over a dozen longitudes around the globe. And a cohesive network of amateur astronomers will have imaging and photoelectric telescopes ready to monitor unusual celestial objects on short notice."

Will astronomers continue to develop larger and larger ground-based telescopes? Sidney van den Bergh of the Dominion Astrophysical Observatory in Victoria, British Columbia, an astronomer focused on galaxies, points out the limits.

"Earth-based telescopes are probably within a factor of two of their ultimate practical size limit," he says. "Furthermore, the quantum efficiency of CCDs is already close to its peak at visual wavelengths. So no more spectacular gains in light-gathering power are to be expected."

Galaxy researcher Tony Tyson of AT&T's Bell Labs in New Jersey sees a revolutionary connection between technologies: "Computers, detectors, and telescopes will merge into one machine, exploring any part of position-wavelength-time-space. Retrieval of multi-wavelength data from archive via gigabit links will become automated. Because of their cost effectiveness, very large special purpose observatories will be constructed to carry out programs by large consortia of investigators. The largest projects, whether in space or on the ground, will be worldwide collaborations."

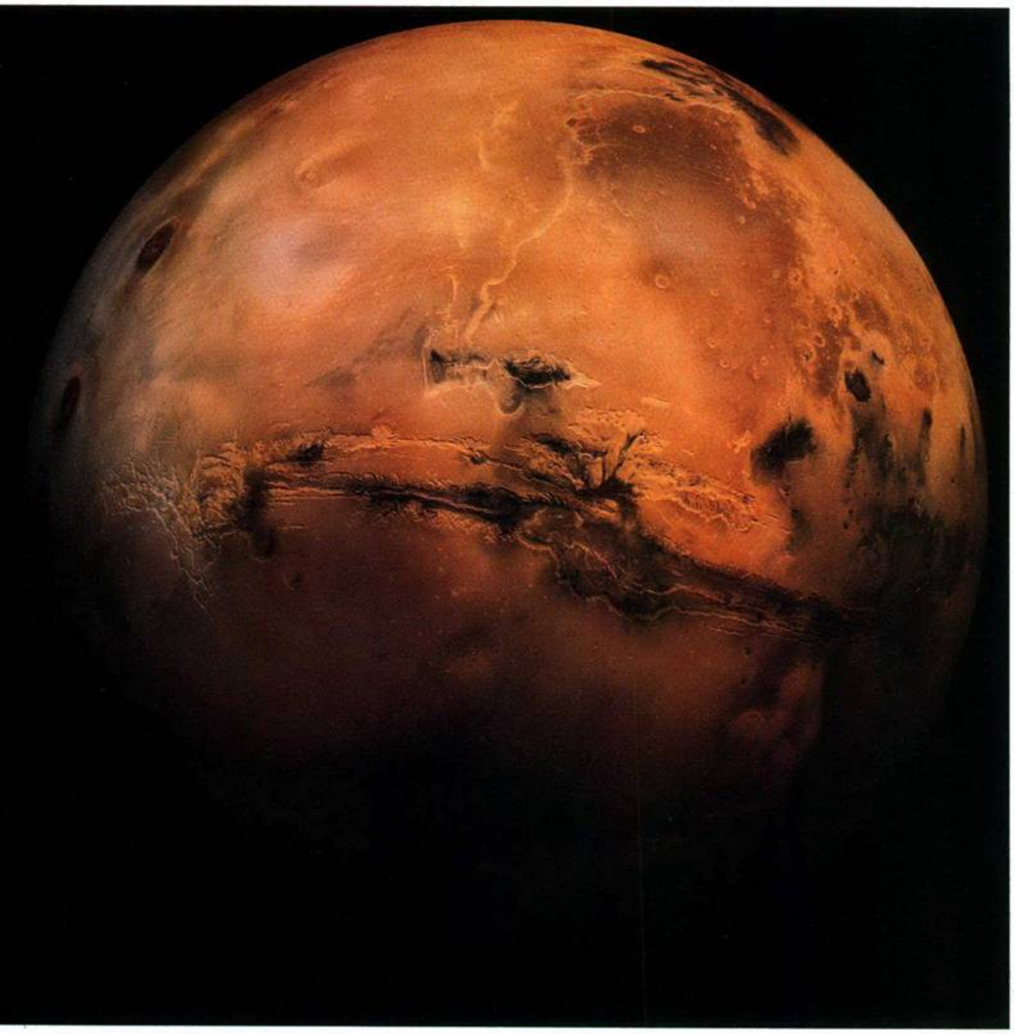


NASA

"What we learn in the solar system will be applied to monitoring and safeguarding our own planet."
— Carl Sagan

"If present trends continue," says Carl Sagan, "the two decades between now and 2013 should usher in a revolution in planetary science. There will have been entry probes into the atmospheres of Jupiter and Titan, and perhaps other giant planets. These will have been landers returning data from the surfaces of Titan, near-Earth asteroids, comets, and perhaps some of the Galilean satellites of Jupiter as well as samples from near-Earth asteroids, comets, and Mars."

Sagan predicts a vigorously revived solar system exploration program. "Mars will have been the subject of intense scrutiny by long-lived roving vehicles. There will be robotic balloons and aircraft flying through the Martian atmosphere, and we will have made substantial progress in understanding how to send humans fairly safely and at a reasonable cost to Mars.



USGS

"Both what we learn about the other bodies in our solar system and the instrumental methods of acquiring the data will be applied to the very real and practical problem of monitoring and safeguarding the health of our own planet."

Mars may not have exclusive rights to the revived manned space program, however. Where else might astronomy take us?

"To the Moon," says planetary scientist Richard P. Binzel of the Massachusetts Institute of Technology in Cambridge. "Although I don't expect that lunar observatories will actually be established within the next two decades, firm plans will be in place to create them on the Moon's surface."

Terzian goes further: "By 2013 manned stations on the Moon will be under development."

Paul W. Hodge of the University of Washington, active in the galaxy field and editor of the *Astronomical Journal*, suggests "we'll have a working observatory on the Moon. It will not be very large by then, but should be at least a beginning."

According to extragalactic astronomer Harold G. Corwin, Jr., of Caltech, "unmanned lunar observatories are a possibility toward the end of the next score of years. Manned lunar observatories may come along in the decade following that."

Planetary scientist Carolyn Porco of the University of Arizona foresees a more ambitious solar system exploration ahead. "Our initial steps have taken us to a new era, where we now stand poised," she says. "Over the next 20 years we will revel in a brief but historic visit to Pluto, in-depth studies of Jupiter and Saturn, an armada of robotic spacecraft landing on Mars, and samples we've obtained from a comet. Our advanced explorations will be accompanied by a new view of our world."

New technologies will also create a boomlet in solar system discovery, as prefaced by last year's find of the "miniplanet" 1992 QB$_1$.

"We stand on the threshold of one of the most profound epochs of discovery in the history of astronomy," planetary geologist Eugene M. Shoemaker of the U. S. Geological Survey in Flagstaff, Arizona. "In the solar system, the increase in our knowledge of the small bodies will be revolutionary. We will discover Earth-crossing asteroids, active and extinct comets, and Trojan asteroids by the thousands. We will explore the source regions of comets and discover families of distant comets orbiting under the perturbing control of Uranus and Neptune.

We will find distant planets roughly comparable in size to Pluto."

"I expect we will have a spacecraft en route to Pluto."
— Richard Binzel

"The dominant issue in the public imagination will be the threat of near-Earth asteroids," asserts radio astronomer Gerrit L. Verschuur of Rhodes College in Tennessee.

"By 2013 the census of these objects will reach 800 and the statistics will reveal that the threat of a civilization-destroying collision is greater than estimated in the 1990s. Research will provide a startling amount of circumstantial evidence that human civilization emerged since the last significant impact, which occurred on the order of 10,000 years ago, and that we have been very lucky to get this far without another."

In terms of planetary exploration, the next twenty years may allow a completion of the first thorough exploration of our home star system.

"We will complete the successful missions of Galileo to Jupiter and Cassini to Saturn," says Binzel. "I expect we will have a spacecraft en route to Pluto to complete the preliminary reconnaissance of our solar system and perhaps a Neptune orbiter on the way to thoroughly study the eighth planet and its moon Triton. Perhaps we'll be looking forward to our first returned sample of a comet, a sample of the stuff from the early solar system."

Planetary researcher Tobias C. Owen of the University of Hawaii cautions that missions that would follow those already underway may be difficult to fund.

"We have started a new phase of Mars studies with the launch of Mars Observer, which should be followed by the Russian Mars 94 and 96 missions and perhaps missions to place a network of stations on the surface before these two decades are finished," he says. "Will there be a Pluto mission? Will there be a comet mission to take the place of CRAF and Rosetta, both of which have failed to find financial support? It is not at all clear."

Revolutionary progress will be made in our understanding of the solar system, according to Hodge. "The history of Mars' atmosphere will be unraveled, using data brought back by manned Martian missions. We'll then know when and why Mars had liquid water and warmer temperatures. And at age 78, I'll seriously be considering retiring from teaching so I can concentrate on research projects that never seem to get done nowadays."

"More powerful telescopes will allow us to detect and study planet-sized bodies around other stars."
— Chris McKay

Christopher Chyba sees a broadening of planetary science and its application to examining the distant history of Earth.

"The 1980s established the Cretaceous-Tertiary extinction as a specific candidate for impact-driven evolution," Chyba says. "The next two decades will see ecologists, paleontologists, and planetologists working together to rethink our overall understanding of the evolution of terrestrial life, in light of random, impact-related environmental catastrophes."

Other astronomers agree that planetary research will increasingly win support as a comparative way of understanding Earth and solar system history. The surge in planetary astronomy "will be driven by an increased interest in Earth as a planet by the scientific community, the major science funding organizations, and the general public," suggests Christopher P. McKay, a solar system expert at NASA's Ames Research Center in Moffett Field, California.

"The more compelling impetus will result from direct observations of other planetary systems. New techniques and more powerful telescopes will allow us to detect and study planet-sized bodies around other stars. Among the phenomena we will examine are the number of planets in the Galaxy, the mechanism for the formation of planets, and the prevalence of Jupiter-sized and Earth-sized planets."

Sagan points to the blossoming of knowledge about planetary systems elsewhere in the Galaxy.

"By 2013 I think it's possible that we will have information about planetary systems in all stages of development around nearby stars, with perhaps dozens of mature planetary systems for us to study," he says.

"These discoveries will be made both by ground-based and by space-borne observatories. We will have a wide variety of systems to examine. We will understand what kind of variation is possible in the masses of the planets in other systems, their spacings, and their other orbital elements, whether there is a correlation between type of planetary system and stellar spectral type. And perhaps — although this is less likely — we will even have information on the chemistry and prospects for life on a few Earth-sized planets in these systems."

"I anticipate a sea change in our understanding of galactic structure and dynamics."
— Brian Skiff

Over the next 20 years, say the astronomers, we'll expand our knowledge of the home Galaxy immensely, understanding its form and perhaps its origin and evolution more clearly than we might have guessed.

"I anticipate a sea change in our understanding of galactic structure and dynamics as a result of very large surveys that are presently underway," says stellar researcher Brian Skiff of Lowell Observatory in Flagstaff.

"The second-epoch Schmidt sky surveys will yield magnitudes, colors, and proper motions for perhaps a billion stars." This widespread collection of basic data goes beyond the Milky Way, Skiff points out. "In the extragalactic realm, surveys underway in collecting photometry and redshifts of large numbers of galaxies promise a resolution (or revolution!) of our understanding of cosmic structure."

"Technological improvements will allow us to do real imaging of the surfaces of other stars," says James B. Kaler, an astronomer at the University of Illinois at Champaign-Urbana who specializes in planetary nebulae. "This will no doubt lead to a better understanding of stellar activity and its relation to solar activity."

> **"Modeling stellar structure and evolution will reach a sophisticated level that will help the theorists sleep at night."**
> — Bruce Carney

"We'll most likely see more sky surveys," says Corwin. "A digital sky survey and a 2-micron sky survey are already in the planning stages. The second Palomar Sky Survey is already underway. These will continue to broaden our vistas in the way the Palomar Schmidt did in the 1950s and 1960s."

Infrared astronomy will lead the way, according to Bruce Carney. "The Gemini 8-meter telescope will be infrared-optimized and the southern 8-meter scope won't be far behind. I'm excited mostly because the infrared gives us remarkable vision: We're able to peer into the heart of our Galaxy, and indeed throughout its disk, and into the dusty centers of merging galaxies, protogalaxies, and high-redshift galaxies."

Galaxy specialist Neil F. Comins of the University of Maine agrees. "Infrared astronomy will make a great contribution in understanding protostellar evolution and early main-sequence properties of stars. And planets will be found around nearby stars."

> **"We'll zero in on a value of Hubble's constant that nearly all astronomers can believe in."**
> — Alan Dressler

Over the next 20 years extragalactic astronomy will take the front seat as the leading edge of astronomical observation and theory. As astronomers confront the "big questions," their techniques will develop into more sophisticated ways of probing the cosmos. Of the more unusual solutions to their problems, astronomers will begin to use astronomical objects as extensions of their tools in much grander ways than they do today.

"Gravitational lenses will have become effective (if de facto) synthesis telescopes, providing closeups of the extremely distant and young universe," says Hodge.

"Among the sought-after goals we'll achieve will be a value of Hubble's constant that nearly all astronomers can believe in," predicts extragalactic astronomer Alan Dressler of the Observatories of the Carnegie Institution of Washington in Pasadena. "We will finally be able to judge whether or not the cherished simple models of the big bang expansion of the universe are valid or not. This is likely to be the biggest crisis for cosmology in the next 20 years."

But Kaler disagrees: "I venture that this problem will not only be unresolved, but will get worse."

Dressler sees a redirection of observational cosmology ahead. "The emphasis," he says, "will shift to the formation of galaxies in the early universe. We will for the first time assemble large samples of young galaxies, realizing a dream of observing the process of galaxy formation as it happened."

> **"After another 20 years we still may not know what the universe is made of."**
> — Stan Woosley

In perfect agreement, David Schramm believes "within 20 years we will solve the basic central problems of physical cosmology. That is, what is the dark matter and how did physical structures form in the early universe." Several research methods will combine to provide an answer, Schramm believes. "But we still won't be able to forecast Chicago weather."

Suggests Huchra: "The centers of the nearest quasars will be resolved, but despite these observations we will still not be able to prove beyond the shadow of a doubt that the responsible engines are black holes."

Supernova specialist Stan Woosley of the University of California at Santa Cruz sees a different picture. "We'll resolve the Hubble constant question and determine the size and age of the universe. During the last decades two unyielding groups claimed two different figures — 55 km/sec/Mpc and 100 km/sec/Mpc — as the Hubble constant value. During the next decade or at most two, observations with the HST and ground-based instruments combined with a better understanding of supernovae and other distance indicators will resolve this debate. The answer will be 65 ± 10 km/sec/Mpc and the age of the universe will be about 10 billion years. With regard to dark matter studies, Woosley cautions that "after another 20 years we still may not know what the universe is made of."

Krisciunas agrees: "It's probably a variety of subatomic particles, but in 20 years we still won't know what they are."

"Astronomers in 20 years will generally agree that we live in an enormous, closed universe produced by an early inflationary episode," asserts Timothy Ferris, a noted astronomy author at the University of California at Berkeley. "We will have arrived at a more-or-less exact value for the Hubble constant — thanks mainly to observations of supernovae and gravitational lenses —but will still be wrangling about the precise contours of intercluster velocity fields from here to Hydra-Centaurus."

Ferris sees even more surprising confirmations in the future. "In reconstructing what happened in the big bang, cosmologists will have recourse to a unified theory of quantum physics — probably some variety of a superstring theory," he says.

> **"How and when should we look beyond our limited discipline to seek a broader understanding of our lives?"**
> — Rudy Schild

Despite astronomers' predictions, the most exciting discoveries and developments may be by their very nature ones that cannot be predicted. "With a new generation of telescopes and spacecraft deployed," says galaxy researcher Rudolph Schild of the Harvard-Smithsonian Center for Astrophysics, "I expect the next 20 years to bring answers to most of today's outstanding questions about the structure of our four-dimensional universe. The Hubble constant, density, missing mass, and past and future evolution are all measurable in the near future, with the biggest advances to come from gravitational lensing."

Schild concludes with the $64,000 question. "As impressive as the instrumentation and astrophysics are becoming, I expect our knowledge of the universe is much too limited, and that measurements within our space-time continuum will never reveal a more vast universe of higher dimension. How and when should we look beyond our limited discipline to seek a broader understanding of our lives?"

"We will know whether there is an abundance of technologically advanced civilizations in our Galaxy."
— Tobias Owen

The audience gasped and "oohed" with curiosity and delight when Carl Sagan flatly stated, "I'd like it if we got an absolutely bona fide, compelling, unambiguous communication from another intelligent species." The subject perennially excites the public and fuels science fiction novels and movies. What do astronomers, who have the most scientific training about the possibilities for the formation of life elsewhere in the universe, think about contacting it?

Jill Tarter, currently a project scientist on NASA's High Resolution Microwave Survey project — the current SETI effort — is hopeful. "Of course I hope the next 20 years will bring the detection of an extraterrestrial technology, proving that we share this universe with others who wonder," she says. "This is a hope, because as powerful as our tools are, we can't promise success."

Woosley proclaims, "With a 1 percent probability, we'll experience [one way] contact with an extraterrestrial civilization by radio."

That's not a very high probability, although it makes a one-way contact hundreds of thousands of times more likely than winning the lottery. Still, even if many civilizations exist in the Milky Way, the distances, wavelengths, search patterns, and other considerations statistically make contact very difficult.

Yet Owen is optimistic: "We will know whether there is an abundance of technologically advanced civilizations in our Galaxy. We may indeed not find evidence for it, but that too will be an important result."

On the other hand, Kaler believes that "no intelligent life will be found by SETI initiatives as advocates look deeper into space. But belief in astrology and UFOs will be stronger than ever."

Sagan takes a wider view: "We will have completed a number of comprehensive surveys of the entire sky for radio signals from extraterrestrial intelligence. Whether the results are negative or positive, they will profoundly influence our views of ourselves and our place in the cosmos."

Anglo-Australian Telescope Board

Discovering other civilizations is a rather ambitious goal to put into any 20-year plan. It's much safer to say that the fields of planetary exploration, advanced telescopic research, Milky Way and extragalactic studies, and cosmology will undergo great and sweeping transformations over the coming two decades, making astronomy an even more lively and enlightening science. Just possibly, humans may again take giant steps into the solar system.

"If humans have not landed on Mars by 2013, we will be very close to doing so," Sagan says. "We will have accomplished the human exploration of at least one near-Earth asteroid. But as is always true in science, the most important discoveries will be made in areas that we are not today wise enough to predict." □

CHEAP

The day of big-budget planetary missions — like Voyager, Galileo, or Cassini — is over. NASA has seen the future and the magic word is "cheap." But what sort of planetary program will result?

by Michael W. Carroll

In an era of scant funds and tight belts, NASA is seeking a different approach to planetary exploration. Gone are the days of multibillion dollar, multispacecraft projects sent off on decade-long cruises. While it acknowledges the risks, NASA is seeking faster and cheaper spacecraft that can be launched both inexpensively and more often.

But can this really be done? In November 1992, over 200 scientists and engineers met in picturesque San Juan Capistrano, California, to prove that it could. NASA is calling this new kind of planetary science mission Discovery.

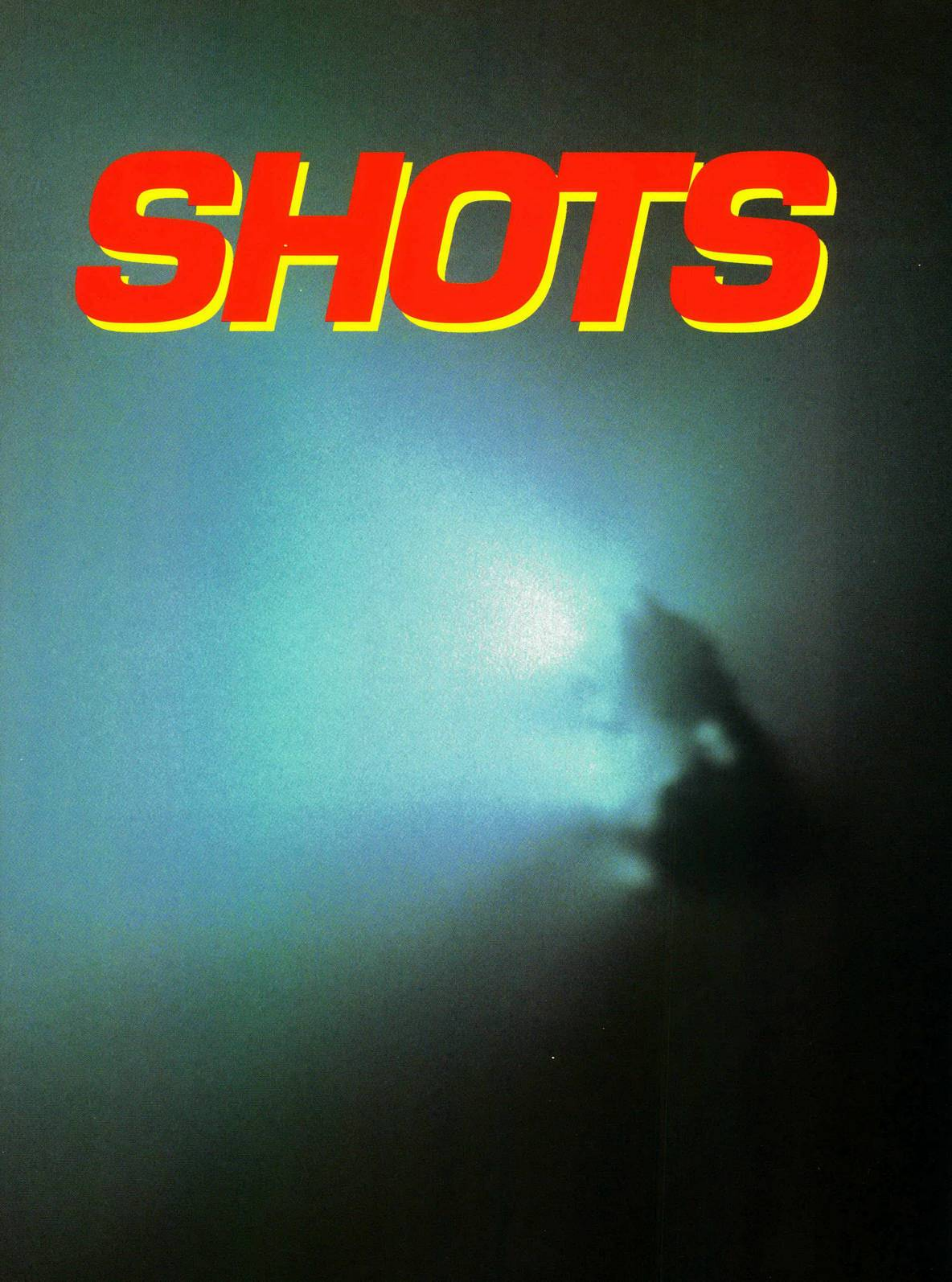
"Each Discovery mission must be done within a budget of $150 million and be launched on a Delta-class or smaller booster," declares workshop organizer Doug Nash of the San Juan Capistrano Research Institute.

"The mission must be completed within three years, which also keeps the cost down. A Discovery mission has tightly focused science objectives and maybe only one or two instruments. This is different

Looming through the foggy coma, the nucleus of Halley's Comet glowed eerily as the Giotto spacecraft flew past it in 1986. NASA's new Discovery program is targeting several comets for investigation by low-cost spacecraft.

Uwe Keller, Max-Planck-Institut für Aeronomie

SHOTS



from previous missions, which had a much wider variety of instruments, pursued lots of objectives, and therefore cost far more."

NASA is hoping that the Discovery mission concept will breathe new vitality into solar system exploration by returning high-quality science more often. Additionally, Nash points out that the missions will be "designed specifically to involve more young researchers" than traditionally participate in the bigger high-profile missions.

Déjà Vu All Over Again?

If faster and cheaper seems to ring a bell, you're right. NASA's quest for inexpensive robot explorers has a rich tradition stretching back to the Pioneer- and Mariner-class spacecraft of the 1960s and early '70s.

NASA's first successful planetary encounter was by Mariner 2, which flew past Venus in December 1962. The little craft was the first in a highly successful series of Mariner planet explorers that went on to chart Mercury, Venus, and Mars. According to one Jet Propulsion Laboratory source, "Only one planetary mission has ever flown for $150 million in today's money — Mariner 5 — and that was a case where the spacecraft was originally configured for Mars and was modified to go to Venus. There was significant technological inheritance. Everything was pretty much the same except the science package."

Inheritance — the use of existing hardware and design — is key to the $150 million Discovery program. The concept has been used before with varying success. For example, several years ago NASA pitched an "Observer Class" of spacecraft to the Office of Management and Budget (OMB). The idea was to build a series of spacecraft to explore the inner planets using designs modified from Earth-orbiting satellites. An assembly line approach and the use of existing technology would, in theory, keep the costs down.

But surprisingly, the idea of an Observer line of semi-standard spacecraft was rejected by both Congress and the OMB. The first mission in the proposed series (Mars Observer) did survive, but it was funded as a single mission only. What then followed could have been predicted. When the planetary science community saw the idea of a series of explorers discarded, they viewed Mars Observer as a one-shot opportunity and piled on state-of-the-art instruments. With the project transformed into a one-of-a-kind mission, engineers treated it in a "business as usual" manner. The result was that Mars Observer rapidly outgrew its tight fiscal origins to become sophisticated and expensive.

NASA's next attempt at a series of cost-effective planetary explorers was the Mariner Mark II class. JPL engineer Charlie Kohlhase, who spent over a decade on the Voyager project, now works on the staff of the Cassini Saturn mission. He tells what happened to Mariner Mark II:

"The Mariner Mark II program was supposed to use a common spacecraft, where you change only the science payload and the propellant load. Otherwise, you had the same fuel tanks, data systems, power sources, and scan platforms. There was a time — a couple of years ago — when several missions were intended as Mariner Mark II flights." The projects planned included the Comet Rendezvous/Asteroid Flyby mission (CRAF), a Comet Nucleus Sample Return, the Cassini mission to Saturn, a Neptune orbiter with atmospheric probe, and a Pluto flyby.

"NASA could not get a steady inflow of funds for the entire Mariner Mark II mission-set," says Kohlhase. "The costs of CRAF and Cassini, the first pair of missions, grew high. Congress said 'These are awfully expensive missions,' and told NASA to cancel CRAF. That pretty much signaled the demise of the Mariner Mark II program.

"The irony was that even though CRAF and Cassini were expensive, removing CRAF saved only $200 or $300 million out of a total of $1.8 billion. CRAF was far less than half the cost. So the Congress didn't pick up a lot of money by canceling CRAF, but the budget was so tight that they felt they just had to do something. Since

Returning to the Moon

Planetary scientists have long dreamed of sending a spaceprobe back to the Moon for a global survey but few guessed that when it flew, the craft would carry the Defense Department insignia.

Clementine is an unmanned probe built to test lightweight sensors for the Pentagon's Strategic Defense Initiative ("Star Wars"). To be launched in late January 1994, Clementine will spend two months in polar orbit around the Moon, imaging its surface and compiling the first global multi-wavelength mineral survey.

Then Clementine will be sent to intercept the near-Earth asteroid 1620 Geographos in August 1994. The craft will fly past Geographos at less than 100 kilometers' distance, imaging the asteroid's surface in detail and in many colors.

The mission sounds like a wonderful marriage of convenience, although for scientists the Clementine spacecraft falls somewhat short of ideal. Designed for military purposes, its sensors have more noise and less signal in their output than scientists would prefer. But even with the drawbacks, most scientists are delighted at the opportunity. After all, Clementine *is* a mission to the Moon (plus an asteroid) and it *will* be launched next January.

Science might even get something more. For safety's sake, the Clementine project is planning to build two similar spacecraft. If the first carries out the full mission, the second would be available to survey more near-Earth asteroids (Eros and Toutatis are possible candidates) or other targets in the inner solar system.

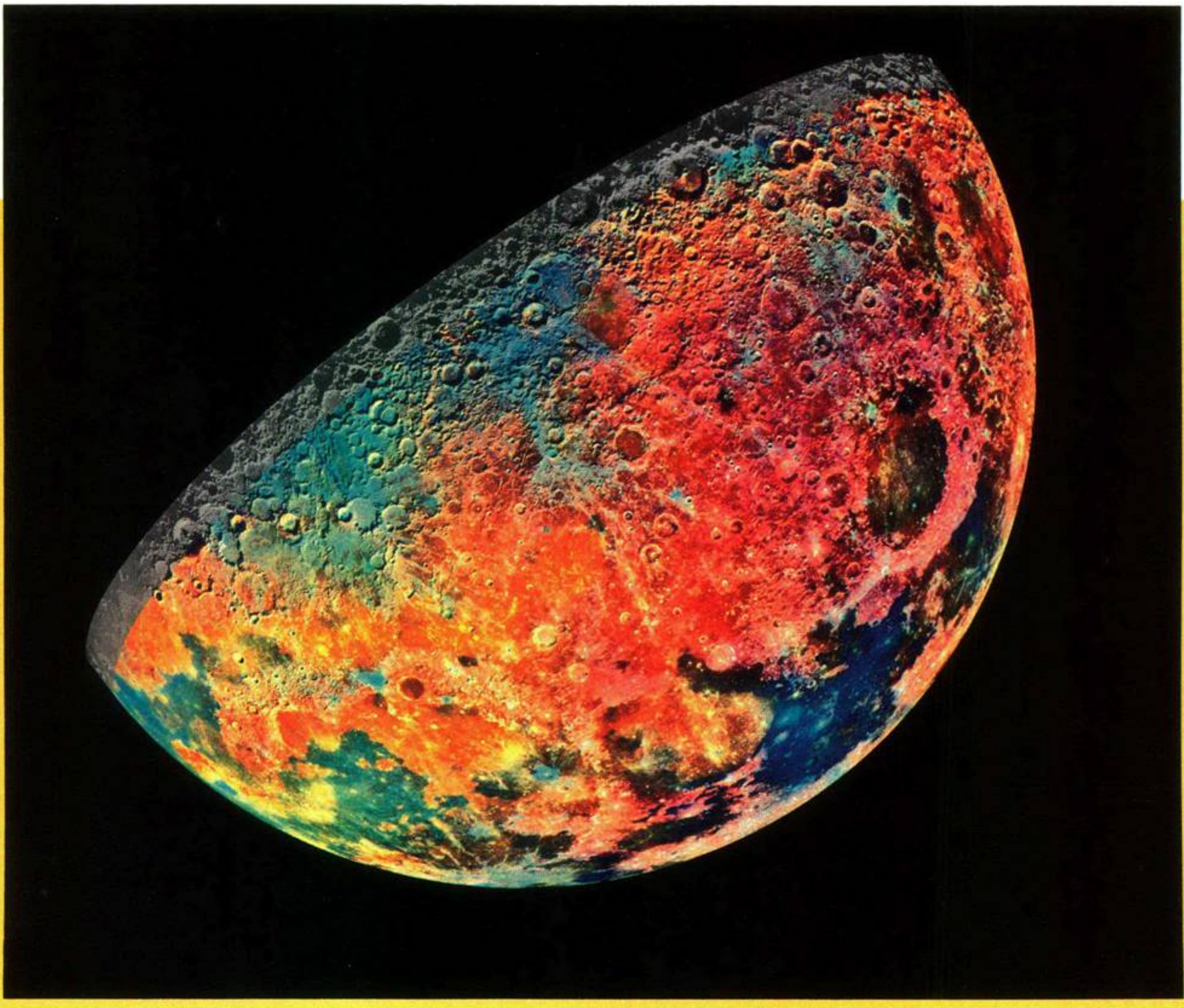
But Clementine is not the only lunar spacecraft in development. Proposed by NASA, Lunar Scout is a mission with two spacecraft and low-noise sensors *optimized for lunar study.* Lunar Scout 1 will carry a high-resolution stereo camera, an alpha-proton X-ray spectrometer to detect major rock-forming chemical elements,

CRAF's cancellation, a Cassini re-design has reduced costs by an additional $250 million."

A Return to Roots

Although the Mariner Mark II concept is dead, several planetary programs are left in NASA's stable. These include the Cassini mission to Saturn (carrying the European Space Agency's Huygens Titan probe), the

Can NASA really build spacecraft faster, cheaper, and better? And launch them inexpensively and more often?



NASA/JPL

and a neutron spectrometer to detect hydrogen (and help search for water at the lunar poles). Lunar Scout 2 has an imaging spectrometer for mineral mapping and a gamma-ray spectrometer for measuring the abundance of elements in the lunar crust. And as scientists carefully track both craft in lunar orbit, they will map the Moon's gravity field to high precision.

The Lunar Scout mission has not yet been approved by Congress, but NASA hopes it will receive funding as a new start for fiscal year 1994. If it does, then Scout 1 would leave for the Moon in mid-1996 and Scout 2 a year later.

Being so close to Earth, the Moon often gets overlooked while missions to more exotic locales get the nod. Yet for planetary science, the Moon is a priceless Rosetta Stone of solar system history — and it sits on our own doorstep. With the advent of Clementine and the possibility of Lunar Scout, scientists are hoping that the long lunar "data drought" may finally be nearing an end.

Tantalizing glimpses of lunar mineralogy came during Galileo's high-speed flybys of Earth and the Moon. Two new lunar missions will vastly improve on such hurried surveys and extend them to the whole lunar globe, thus completing a task that has eluded planetary scientists for two decades.

Each Discovery mission must be done for $150 million or less and be completed within three years.

Pluto Fast Flyby mission (see box on page 46), and MESUR, the Mars Environmental Survey project.

Cassini/Huygens is the last of the big, custom-designed missions; NASA is now returning to its roots, with a smaller-scale approach to space exploration using Discovery-class missions. First in the Discovery line-up is the MESUR/Pathfinder mission to Mars (see box on page 44). The director of NASA's Solar System Exploration Division, Wes Huntress, describes its role:

"Essentially the MESUR/Pathfinder mission is intended to test a very low-cost means of getting science packages to the surface of Mars. After we've proven we can do that, then the system becomes available to the science community to carry whatever packages they're interested in to the Martian surface.

"It's a pathfinder in several ways. First, to learn how to do low-cost planetary missions. Second, to develop a very low-cost means of putting science packages on Mars. Third, as a pathfinder for the whole MESUR Network, a proposed set of multiple spacecraft to survey the Martian environment over the course of several years. And fourth, as the beginning of an evolutionary Mars-lander system that can evolve later into more challenging things, such as sample return missions.

"It's our pathfinder to the surface of Mars for the future."

After MESUR/Pathfinder, next on NASA's Discovery agenda is the Near Earth Asteroid Rendezvous project, or NEAR. NEAR is a low-cost, compact spacecraft that will complete history's first long-term exploration of an asteroid. The Applied Physics Laboratory of The Johns Hopkins University heads the mission.

"Our primary mission is to rendezvous with the asteroid 4660 Nereus," says NEAR program manager, Tom Coughlin. "Other asteroids are also under consideration, but the Nereus baseline launch is January 1998. About 9 months after launch, we will first fly past an asteroid named 2019 Van Albada. We'll come within a thousand kilometers of it with a relative speed of about 11 km/second.

"After the Van Albada encounter, we'll spend about 8 months at Nereus, orbiting about a kilometer above its surface with a suite of instruments yet to be selected. The solar power arrays are the only moving mechanism on board. Everything else is fixed: the antenna, the instruments — everything — and this keeps the design simple."

NEAR mission costs are also kept at a minimum by a short development time and a narrow range of investigations. Asteroid encounters occur at about 1 astronomical unit (AU) from the Sun and the spacecraft travels only slightly farther out than 2 AU, Coughlin said. This means NEAR can rely on solar panels for electric power, instead of much more expensive radioisotope thermoelectric generators (RTGs), needed on craft bound for Jupiter and farther. If the maneuvering fuel holds out and the craft remains healthy, controllers will have additional opportunities for flybys of asteroids or comets after the Nereus rendezvous, using Earth gravity assists to swing NEAR toward targets for an extended mission.

"Discoveries" for the Future

If Discovery missions represent NASA's planetary exploration future, then what projects lie ahead for the program? To define these, NASA convened last November's Discovery Mission Concept Workshop in San Juan Capistrano.

"We wanted to find out from the science community what ideas they might have that would make a real program out of this," says Wes Huntress. He and the evaluation team were pleasantly surprised. "There were 73 concepts submitted," he marvels. "That was surprising in itself, and it was very satisfying that there were so many good ideas. Out of the 73 concepts, about a dozen or two look like they have a chance of actually fitting into the very confining Discovery program definition."

Would-be mission scientists presented their concepts to the workshop's evaluation panel for review. The proposals fell into four categories: Atmospheres (with 14 mission concepts); Dust, Fields, and Plasma (15); Small Bodies [such as asteroids] (23); and Solid Bodies [planets] (21). As Carl Pilcher, chief of exploration planning for NASA, puts it, "The process was difficult, because there were far more good ideas presented for Discovery missions than we have the resources to study this year."

The wide spectrum of proposals included Mercury orbiters, comet sample return missions, Martian microsatellites, a flock of lunar missions, an Io mapper, various Venus and Mars probes, asteroid explorers (including a Chiron craft), gas giant orbiters, and a search for Earth-sized planets orbiting other stars.

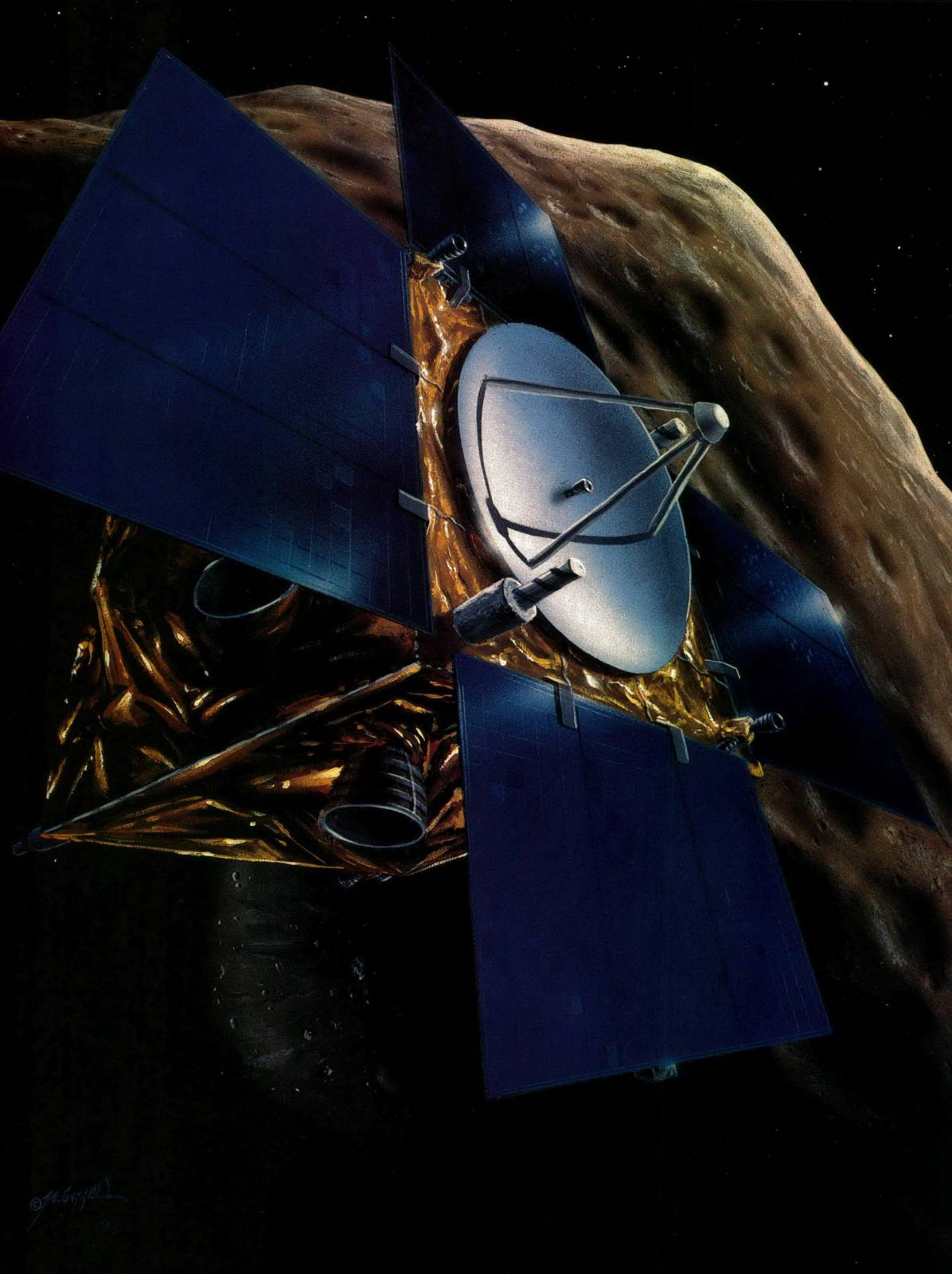
"The purpose of the workshop," explains Pilcher, "was to increase the base of candidates capable of submitting proposals." The Discovery group in effect helped scientists prepare proposals that would work under the strict Discovery guidelines. The workshop was important enough to draw a Who's Who of NASA's bigwigs, among them Administrator Daniel Goldin. It also drew some of the most clever minds in the industry, as proven by the number of ingenious concepts.

Anatomy of a Discovery Proposal

One proposal was called REAAct. One of those

Michael Carroll

Boxy but capable, the Near Earth Asteroid Rendezvous spacecraft is one of NASA's new line of Discovery spaceprobes. These feature simple instrument packages, short construction times, low costs, and a quick science return.

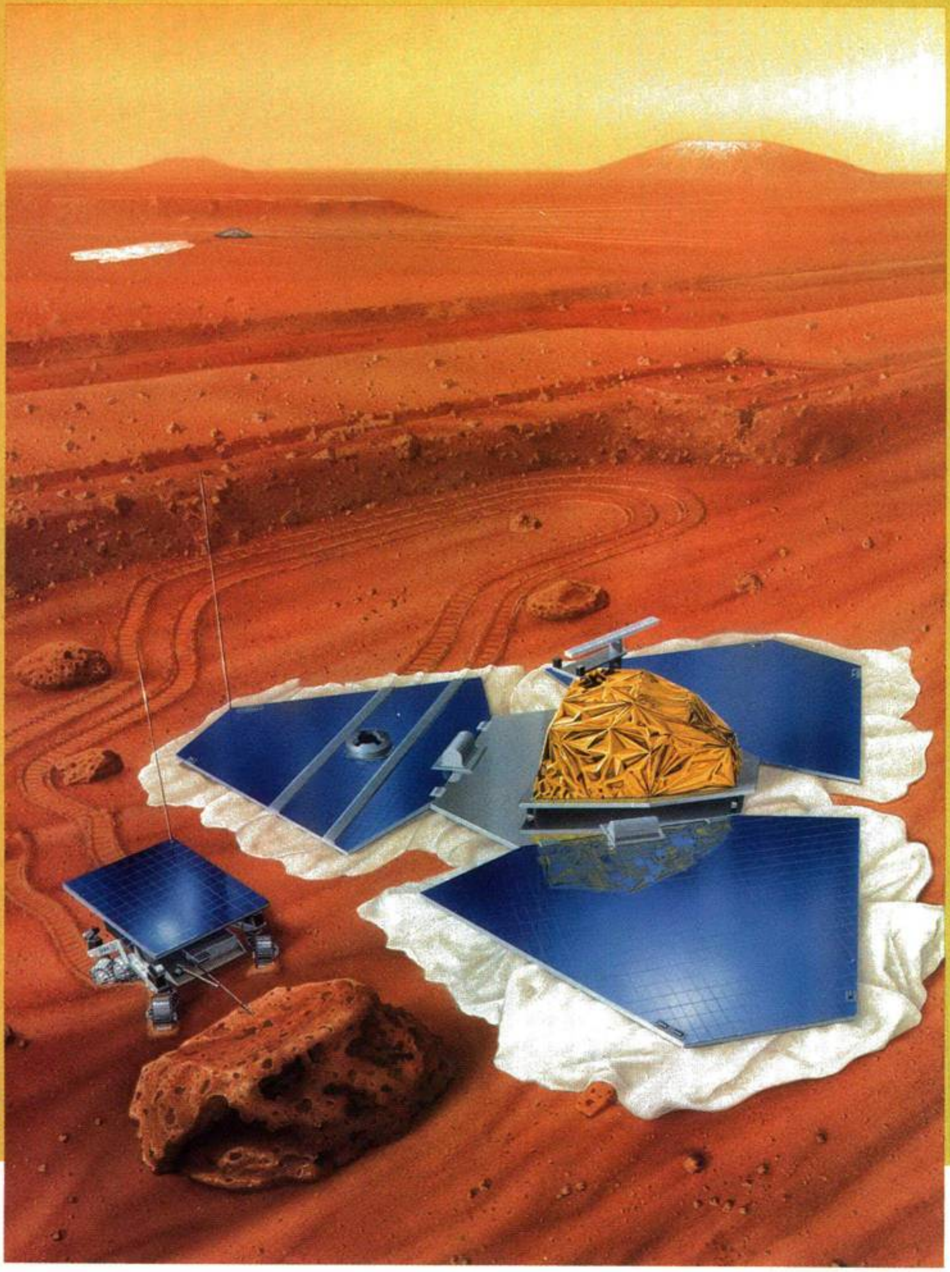


Taking the MESUR of Mars

Seventeen years ago this summer, Viking plopped two landers on the surface of Mars. While they failed to detect Martian life, the landers nonetheless showed the immense value of putting geophysical stations on another planet.

Mars is a highly complex world, second only to Earth among the terrestrial planets. It has volcanoes, sediments, seasons, polar caps, clouds, winds, storms — even precipitation. But to get a grip on all of Mars' diversity, scientists need more data than the two now-defunct landers provided; what's needed is a network of instruments on the surface. Hence MESUR, or the Mars Environmental Survey mission.

MESUR (pronounced like measure) is really a collection of missions under a single name. If



NASA/JPL

Scratch-and-sniff will be the mission for the microrover, a possible component of NASA's upcoming MESUR/Pathfinder spaceprobe to Mars.

Discovery proposals include Mercury orbiters, comet sample return missions, an Io mapper, and asteroid explorers.

ever-present acronyms in space sciences, this one stands for Rendezvous with Earth Approaching Asteroids. REAAct was the brainchild of Daniel Britt and Mark Sykes of the University of Arizona.

"We had this wild idea that we'd just been chewing on over beers," says Britt. "And then we tried to flesh it out in the modest time available." The time available was a scant four weeks, during which Britt and Sykes had to put forth a detailed letter of intent, with the complete proposal due two months later. Some researchers had been working for many years on concepts to fit the Discovery framework, but not Britt and Sykes. "We literally started from scratch," Britt says.

carried out fully, MESUR would place anywhere from 8 to 24 landers all over the Red Planet. These would investigate such phenomena as Martian weather, geology, seismology, and the chemistry of its surface.

MESUR, however, will start small. The JPL-designed MESUR/Pathfinder is the first in NASA's new series of Discovery missions. As the spacecraft name suggests, it is intended to pioneer ways of landing relatively small instrument packages on Mars. Also befitting its name, Pathfinder is sparsely instrumented, with only a camera (capable of recording 360° views of the landing site), an alpha-proton X-ray spectrometer, an atmospheric structure instrument, and perhaps a seismometer.

While MESUR/Pathfinder's science package is smaller (and cheaper) than Viking's, it has one startling addition: a kind of Duracell Bunny. In actuality it is a 6-wheel microrover, the first Martian spacecraft dispatched to range freely over its immediate surroundings.

The little rover isn't a sure thing; budget considerations may rule it out. But in hopes it will be included, mission planners have designed a vehicle about 24" long by 18" wide and 6" high. It may be solar powered or it may derive power from the lander by means of a tether. Weighing 16 pounds, it would roll along at a top speed of about 1 yard per minute. It is designed to carry a camera and perhaps also a rock chipper. It will also carry the mission's alpha-proton X-ray spectrometer (which will go on the lander if the rover isn't flown).

Despite the long round-trip time for radio signals from Earth (at least 10 minutes and often longer), mission scientists plan to "drive" the rover from Earth. Although the microrover may remain within about 30 feet of the lander, a camera on the lander will serve to locate it during its travels.

The MESUR project is also exploring ways to make the mission more international. Possible participants are the European Space Agency, Russia, Japan, and Italy among others.

The central idea of REAAct was to target asteroids that are coming very near Earth, typically within a few Earth-Moon radii. Because known asteroids don't do this very often, REAAct invests in an extensive search for small, Earth-approaching asteroids. Four spacecraft are placed in lunar parking orbit to await the discovery of inbound asteroids. When a candidate is found and its orbit computed, one of the craft departs from lunar orbit, using the Moon's orbital energy and Earth's gravity to send it toward an asteroid rendezvous. There it would deploy a small package to the surface for in situ studies. Each craft would be launched to the Moon when a known asteroid was due for an encounter within six months. This ensures a worthwhile mission should no new targets appear.

Multiple spacecraft was one of the cost-saving devices used by Britt's team: "If you try to do a Discovery mission the old way, it can't be done for under $150 million," Britt explains. "The old way of doing business was that you could never afford to fail. Missions ended up spending lots of money for multiply redundant quality control. You spend money for highly tested parts and so forth and that just drives up the cost. The way we dealt with that kind of risk was that instead of having one mission for one Discovery budget, we proposed doing four.

"Instead of gold-plating one spacecraft, we tin-plated four."

Idea in hand, Britt and Sykes were now faced with putting together a team of researchers and engineers who could make the mission a reality for less than $150 million.

"I knew the business rep for civilian satellites at TRW, a satellite company," recalls Britt. "So I called him up and asked for help. TRW has a lightweight satellite that's useful in a lot of these applications. If you buy the Class C model, which has reduced redundancy, you can get it cheap. Then he gave me the name of someone in their instrument section who had instruments that I could perhaps use. Sure enough. That worked out pretty well, and we got support from McDonnell Douglas on orbits and launchers and things like that.

"It was pretty amazing. You call these guys up cold and say 'Help us out and we'll see if we can throw some business your way,' and they do!" Armed with engineering and support teams from TRW and McDonnell Douglas and with an impressive 21 member science team, Britt was ready to present his proposal in San Juan Capistrano. Three months later, he would know the outcome.

The Shape of Flights to Come?

"What we have decided to do," says Wes Huntress, "is to fund a couple of these concepts this year and a few more next year in order to prepare them for possible development.

"We chose eleven for study this year and we have another set of very highly regarded concepts that we've deferred for a while. This is because of the need to gain approval for foreign partners or because we wanted some more clarification on how they would fit into the program or because they needed technical development before we felt they could be competitive.

"We will give a very low level of funding to several this year in anticipation of more funding next year."

The 11 concepts chosen for study this year are the following:

Mercury Polar Flyby. This Lunar and Planetary Institute proposal sends a craft like Mariner 10 on a flyby orbit to loop past Mercury at least three times. The mission is to study Mercury's poles and map its uncharted regions.

Hermes Mercury Orbiter. From JPL, this Mercury explorer would orbit the planet, observing its surface, rareified atmosphere, and magnetosphere.

Venus Multiprobe. This Harvard University design is based on the Pioneer Venus small probes. It delivers an atmospheric-structure instrument package and 14 small entry probes to one hemisphere of Venus, where they will profile the atmosphere's structure from 65 km to the surface, detailing winds, temperature, and pressure.

To Pluto, in a Hurry

As the last unvisited planet in the solar system, Pluto is too good a target to ignore. But if we want to see one of the planet's most interesting features, the spacecraft had better get there soon — before Pluto's atmosphere totally chills out.

The Pluto mission, called the Pluto Fast Flyby (or PFF), is being developed at the Jet Propulsion Laboratory and has the enthusiastic backing of NASA Administrator Daniel Goldin. The mission is a flyby because that's the cheapest way to reconnoiter a planet, and it's fast because celestial mechanics decrees it. It's also fast in the sense of *urgent,* because Pluto is moving away from the Sun and entering upon a centuries-long deep freeze. Its present tenuous methane atmosphere will soon become a layer of frost on Pluto's surface, and nobody alive today will be around to see it reappear when Pluto warms up at its next perihelion — in A.D. 2237.

The Pluto Fast Flyby is like a Formula 1 spacecraft: stripped to essentials and focused on just a few tasks. Whereas Voyager weighed 800 kilograms and Galileo 1,500 kg, PFF weighs just 150 kg. Only three instruments are on board: a visible-light imager and ultraviolet and infrared spectrometers. These will map the surfaces of Pluto and its moon Charon and study their composition. The mission will also probe the density, composition, and winds of Pluto's atmosphere by studying the way the craft's radio signals are distorted when PFF passes behind the planet.

Mission planners want to build two spacecraft for safety's sake and to enhance the science return. The fast-flyby concept means that each craft will travel too swiftly to image clearly more than one side of Pluto and Charon at closest approach. For global coverage scientists need two craft, timed to arrive half a Pluto-rotation apart. And if scientists let about a year pass between the two flybys, they may see changes in the atmosphere as it freezes out. This could reveal important information that would be missed if the flybys occurred in quick succession. The delay also lets scientists fine tune the second encounter using the results of the first.

If work begins on PFF in 1994 or '95, plans call for a launch in 1998 and the first flyby some 8 years later. Trimming the spacecraft's weight to 110 kg could shorten the flight time to 6 years. Scientists expect Pluto's atmosphere will disappear by roughly 2015, so time is of the essence. The mission cannot afford the long roundabout cruises that the heavy Galileo and Cassini craft must use to get to their targets. And unlike past outer-system missions, PFF will have to forego encountering Jupiter; planners don't want to load the craft with the heavy instrument shielding the dangerous Jovian radiation belts would require.

So to get the PFF spacecraft out to Pluto in a hurry, mission planners envision launching with the powerful Titan IV/Centaur rocket — or maybe even using Russia's mighty Proton booster. Either one could send PFF off from Earth at high speed on a direct trajectory.

Next stop, Pluto.

Rapidly closing in on Pluto and Charon, the Pluto Fast Flyby spacecraft will offer Earthlings a good look at the solar system's last unvisited planet and its big moon.

Venus Composition Probe. The University of Colorado is proposing a direct-entry spacecraft that measures atmospheric structure and composition from 75 to 42 km altitude during a parachute descent. A pressure vessel separates and continues to the surface. Hardware is based on Pioneer Venus and Galileo.

Mars Upper Atmosphere Dynamics, Energetics, and Evolution Mission. Timothy Killeen of the University of Michigan envisions a Delta-launched spinning spacecraft in a highly elliptical Martian orbit. The craft would study the upper atmosphere and ionosphere.

Comet Nucleus Tour (CONTOUR). Cornell's Joseph Veverka would like a single 5-year mission to encounter three comets (Encke, Tempel 1, and d'Arrest). The mission would begin in August 2003 and would concentrate on nucleus structure, composition, and comet processes.

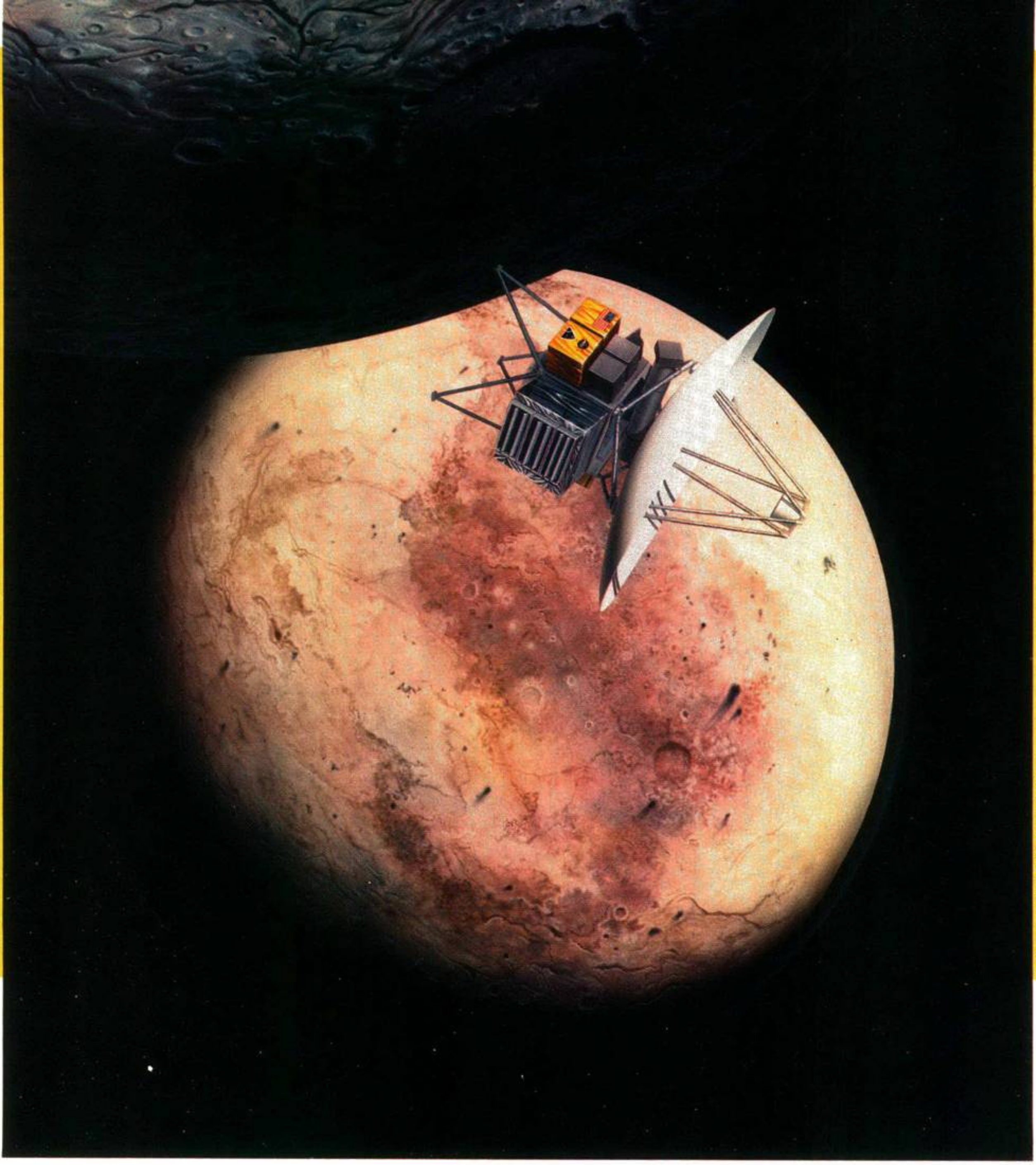
Small Missions to Asteroids/Comets (SMACS). According to Michael Belton of the National Optical Astronomy Observatory, this mission launches four small spacecraft on Pegasus XL boosters at the end of this decade to a primitive object (a C-type asteroid, the most common type), a highly evolved igneous object (an M-type, or metallic, asteroid), a moderately active cometary nucleus, and an extinct or dormant comet nucleus.

Comet Coma Chemical Composition (C^4). This spin-stabilized, solar powered spacecraft would rendezvous with a comet at or near perihelion and fly with it for 100 days. The coma would be sampled periodically.

Near Earth Asteroid Returned Sample (NEARS). In a mission not to be confused with NEAR, the Near Earth Asteroid Rendezvous (see page 43), planetary geologist Eugene Shoemaker calls for the return to Earth of samples from six different sites on a near-Earth asteroid. The low-cost ceiling would be met by using "significant hardware heritage" from the NEAR spacecraft and General Electric re-entry capsules.

Earth Orbiting UV Jovian Observer would place a telescope in distant Earth orbit where it would spend

NASA hopes to breathe new vitality into solar system exploration by returning high-quality science more often.



NASA artwork by Pat Rawlings/SAIC

nine months of its one-year lifetime observing the Jovian system.

Solar Wind Sample Return. This craft would fly outside of Earth's magnetosphere for two years, returning solar wind constituents to Earth for analysis. This mission also has the capability of being piggybacked on another mission.

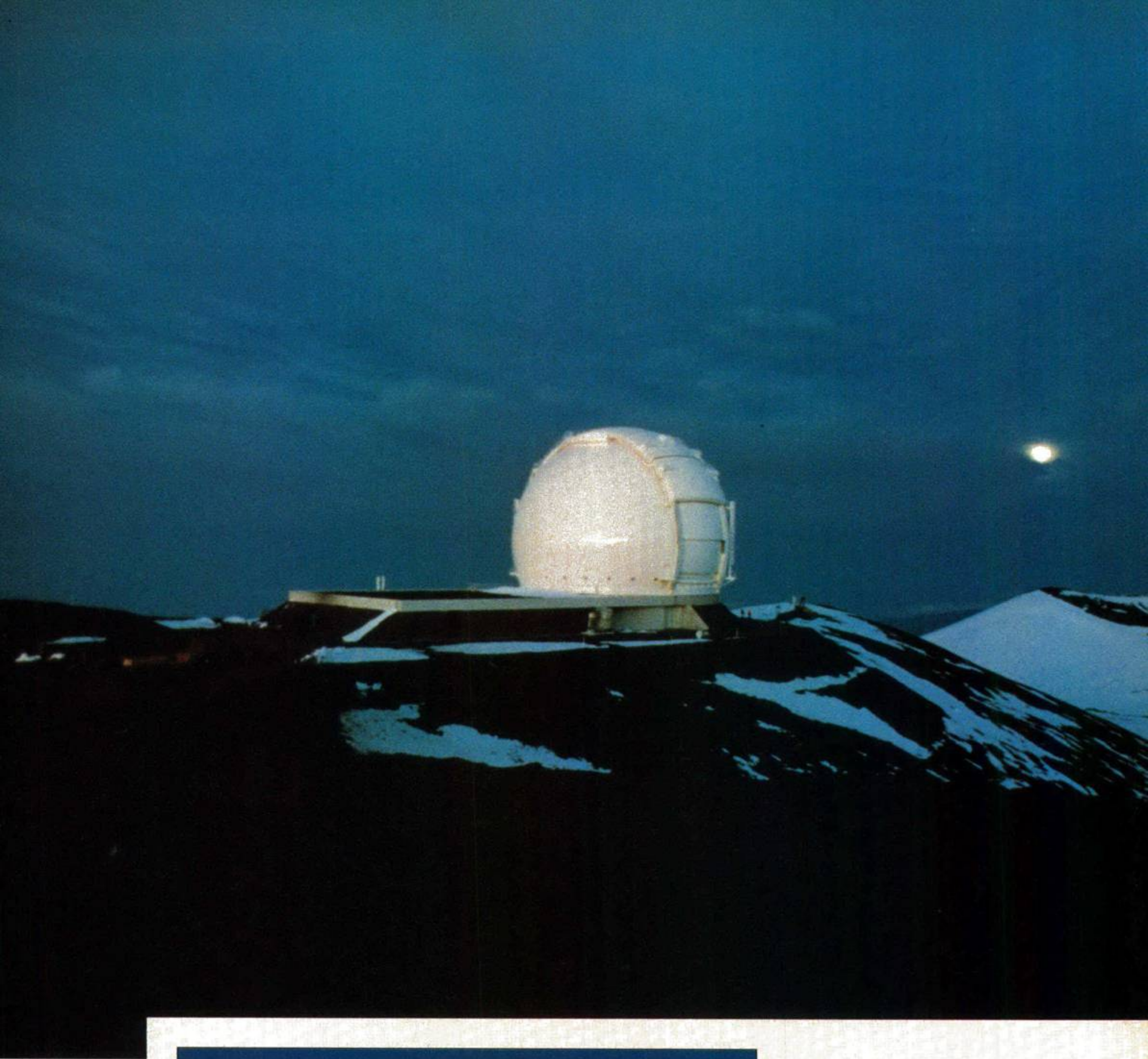
Conspicuously absent from the list are flights to the outer planets. According to NASA's Carl Pilcher, outer planet missions were excluded "for reasons of flight time, the RTG cost, and scheduling issues." Pilcher points out, however, that outer planet missions may be studied in future Discovery projects.

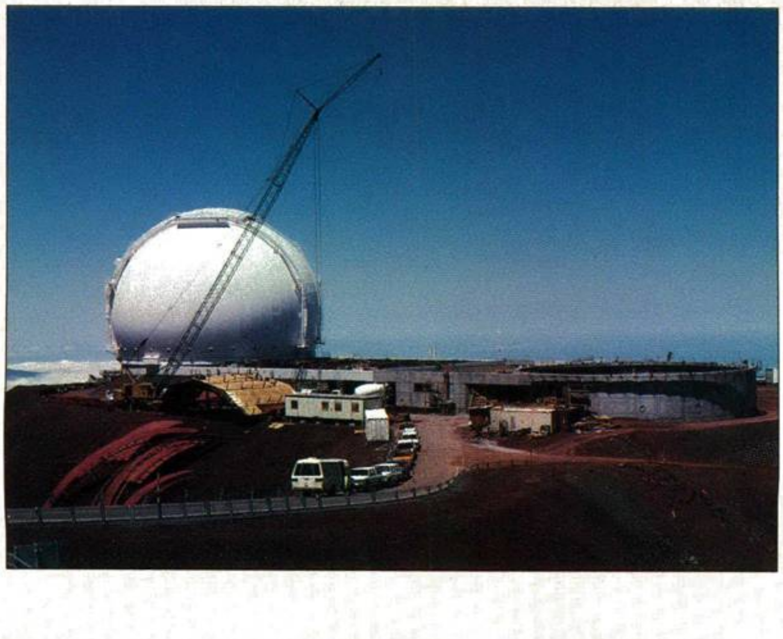
Dan Britt and Mark Sykes' proposal was not numbered among those recommended for initial funding. Like most researchers in his field, Britt is undaunted. "I don't think we're going to give up on it. I still think it's a good idea and that we can do this mission cheaper and better than most."

The Discovery missions are bringing renewed optimism within many areas of planetary sciences. Says JPL's Charlie Kohlhase, "We're hoping that the Discovery missions will recapture some of the cometary, asteroid, and planetary science that has been lost to recent big funding cuts."

NASA's new emphasis on faster, cheaper, better planetary explorers falls right in line with the budget austerity programs of the Clinton administration. As the budget sword slices into already anemic space science funds, Discovery-class missions may offer the best — and perhaps the only — chance to keep our nation's planetary program alive. ☐

Michael W. Carroll is a space artist and journalist living in San Diego.





Both photos by California Association for Research in Astronomy

Keck's Twin

The monster 10-meter-diameter Keck I telescope (above) starts its science duty this year as astronomers commission five newly built spectrometers and infrared cameras. When the telescope gathered its first light with only 9 of its 36 mirror segments in place, it already equaled the light-gathering power of the 5-meter Hale telescope. Now the telescope, which sits atop the extinct volcano Mauna Kea on the island of Hawaii, is the largest in the world. Soon it will be joined by a twin.

Construction on Keck II has begun,

Keck II under construction on Mauna Kea

Dawn of a new era: BIG SCOPES

The giant Keck telescope in Hawaii was just the first. In the next decade, astronomers all over the world will see a dozen more with diameters of six meters or larger.

by Robert Bunge

with completion expected in 1996. This scope, like the first, is being built by the University of California and Caltech, with financial assistance from the W. M. Keck Foundation. Keck II will sit just 85 meters from Keck I. Although the two telescopes can operate independently, astronomers also plan to link the two telescopes, combining their images optically to produce a resolution comparable to that of an 85-meter telescope.

Mirror segments for Keck II started arriving in late 1992. Instead of going into storage, they are replacing segments in Keck I's mirror. Kodak has ion-figured the new segments to precisely polish the mirrors' surfaces, something they didn't do to the original Keck I segments. Present Keck I segments will be sent to Kodak for ion-figuring and then transferred to the Keck II mirror.

Astronomers are power hungry. They hunger for the power to see fainter galaxies than ever before and to resolve details in distant objects such as quasars. Traditionally, bigger and bigger scopes have fed this hunger. But after the 5-meter Hale telescope on Palomar Mountain and the Russian 6-meter telescope, big-scope building took a rest. Then, in the last decade, a few pioneering projects like the 10-meter Keck telescope on Mauna Kea in Hawaii and the Astrophysical Research Consortium's 3.5-meter telescope on Apache Point in New Mexico have proved the technology for the mirrors, mounts, and operation of a new generation of large telescopes. A dozen giant scopes — Keck II, Magellan, Subaru, the 6.5-meter MMT, the Large Binocular Telescope, the twin scopes of Gemini, the Spectroscopic Survey Telescope, and the four scopes comprising the Very Large Telescope — will gather their first light before the end of this century.

Rather than continue to build telescopes in the molds of their predecessors, astronomers have combined a change of tactics with new technology to make telescopes larger than anyone could have imagined 20 years ago. For example, improvements in computers and drive motors made possible a switch from equatorial mounts (one axis points to the celestial pole) to alt-azimuth mounts (simple up-down and left-right axes), saving lots of money and making the mount more sturdy.

Other innovations seek to improve image quality. Years of study at present observatories have revealed the multitude of causes of image blurring. Backyard astronomers know that one source of image blurring or "seeing" is Earth's atmosphere. But astronomers have found that many of the causes of image blurring reside in the telescope enclosure itself.

New designs place heat sources, including the astronomers, far from the scope and open the enclosure so air can circulate freely around the telescope to help keep it at nearly the same temperature as the outside air. Some telescopes sit entirely outside to minimize turbulence and its associated image blurring caused by air flowing around or over the telescope enclosure.

Changes in the telescope tube also help improve image quality. The new scopes have their tube structural members far from the light path. For telescope parts where this can't be avoided, insulation will keep heat from the metal structure from disturbing the light path. This is particularly crucial for telescopes that look at the sky in the infrared because the radiation emitted by the warm telescope is nearly equal to that coming from the astronomical object, which makes it difficult to observe the object. Yet another innovation actively cools the primary mirror with forced air to maintain a constant temperature across the mirror. These new dome and tube designs will enable astronomers to capture details as small as 0.1 arcsecond with some of the new scopes.

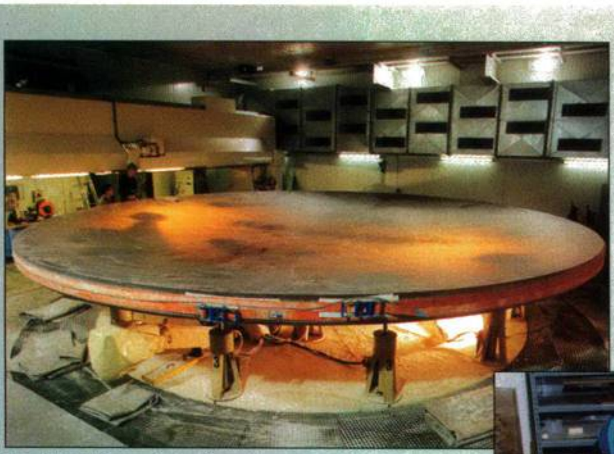
Improvements in mirror technology also have made the leap in telescope aperture possible. Some telescopes, like the Keck, use segmented mirrors. The Keck telescope has shown that

Making BIG Mirrors

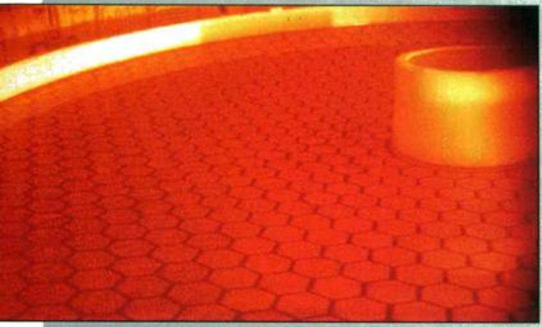
Big telescopes need big mirrors. Some scopes will use conventional mirror technology to cast the mirror but in segments, like the Keck. Precise positioning mechanisms keep the segments aligned to produce high-quality images. The Very Large Telescope will use four one-piece mirrors made of ultra-low-expansion glass by the Schott Glaswerke, but these mirrors are being spuncast to give the mirror the concave shape needed to focus light. Spincasting allows the use of a thin lightweight mirror, instead of thick heavy mirrors produced by conventional mirror making.

Corning is using a different approach in building the Subaru and Gemini mirrors. They cast a mirror in segments and then fuse the segments together in an oven. The one-piece mirror then receives its concave shape by reheating in an oven containing a properly shaped mold.

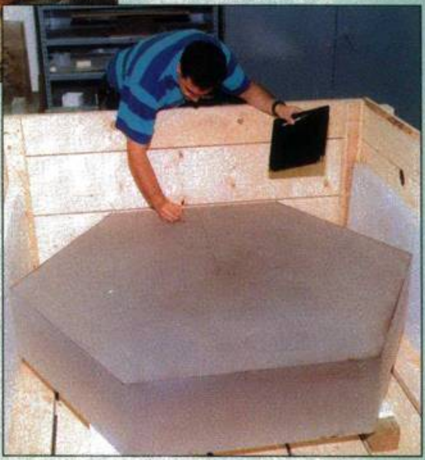
Roger Angel and his team of opticians at the University of Arizona mirror lab also spincast mirrors, but their mirrors have a hexagonal rib structure that crisscrosses underneath the mirror surface. This allows the mirror to be light and yet permits air to flow through the mirror to minimize changes in the mirror's shape caused by temperature fluctuations. This flow-through design allows them to use borosilicate glass, which is similar to the Pyrex glass used in backyard telescopes.


Schott Glaswerke

First VLT 8-meter mirror

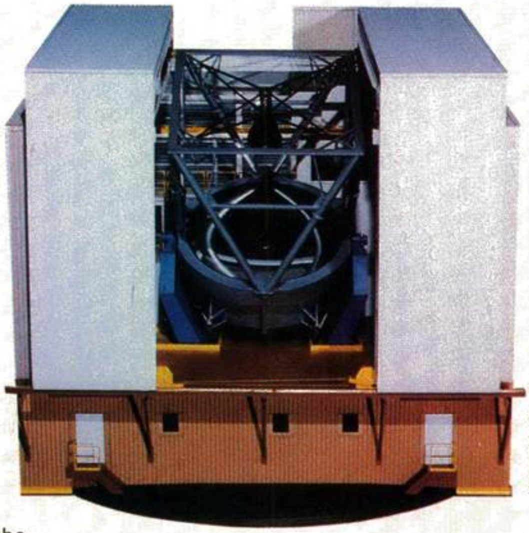

UA Steward Observatory

Casting the 6.5-meter MMT mirror


Corning, Inc.

A Subaru mirror segment

One Eye Is Better Than Six


Howard Lester

When the Multiple Mirror Telescope (MMT) was built in 1979 on Mount Hopkins, south of Tucson, Arizona, it used the then-novel idea of combining the light from six 1.8-meter mirrors to produce the light-gathering ability of a 4.5-meter telescope. While this telescope has worked successfully, astronomers' everlasting quest for more light drove the owners, the University of Arizona and the Smithsonian Institution, to upgrade the existing telescope structure to hold a single 6.5-meter mirror.

The University of Arizona mirror lab spuncast the new f/1.25 mirror in April 1992. Polishing the mirror will take about one and a half years. When the mirror is set in place in late 1995 (first light is expected in early 1996), the "new" scope will have double the light-gathering power of the old instrument. The useful field of view will increase from just three arcminutes to about one degree, twice the diameter of the Full Moon.

Building renovations will start in the summer of 1994 to accommodate the larger telescope. Engineers will decommission the present MMT in mid-1995, replacing the cell that supports the mirrors in the telescope. Astronomers plan to recycle the six 1.8-meter mirrors into an interferometer. The new scope will retain the name MMT, but it's unclear what the letters will then represent. Favorite candidates for the scope's new name are Mono Mirror Telescope, Monolithic Mirror Telescope, Mammoth Mirror Telescope, Mighty Marvelous Telescope, and Minor Misnomer Telescope.

The Very Large Telescope

Being built by the European Southern Observatory, the Very Large Telescope, or VLT for short, is an array of four 8.2-meter telescopes that can operate as four separate instruments or in a combined or interferometer mode. The interferometer mode has the resolution of a 120-meter telescope and the unprecedented light-gathering power of a 16.4-meter telescope. Hundreds of computer-controlled supports will permit the use of mirrors that are only 30 centimeters thick. Schott Glaswerke is spincasting the blanks from an ultra-low-expansion glass that allows the mirror to hold its shape as the temperature changes. REOSC Optics in France will polish and figure the mirrors.

The VLT will be built on Cerro Paranal, about 90 miles south of Antofagasta, Chile. Engineers originally considered roll-off enclosures or inflatable domes but have settled on fixed cylindrical enclosures to better protect the scopes from the wind. Three Italian firms have started bending the metal to build the huge telescopes, and instrument groups are starting to build the cameras and spectrometers. Construction at the site has started and erection of the first VLT scope will start in 1995.

with actuators and sensors it is possible to keep many mirrors in precise alignment.

Other new telescopes will continue to use traditional one-piece mirrors, but with a twist. The mirrors in modern telescopes have fast f/ratios that would require extremely thick and thus heavy pieces of glass if the concave shapes of the mirrors were ground conventionally with abrasives. Instead many of today's mirrors are spuncast. Opticians melt the glass and then, while the glass is molten, spin the oven. The spinning motion gives the mirror its concave shape. Mirrors no longer need to be ground to shape, saving years of effort. Opticians merely need to polish and figure the mirror's surface.

Another advance in mirror technology is stress-lap polishing. The extreme concave shape of a fast-f/ratio mirror makes polishing with standard tools impossible. A deformable tool, called a stressed lap, can adjust precisely to the exact shape needed to polish the mirror across its entire surface. This technology produced the 3.5-meter mirror for the Wisconsin-Indiana-Yale-National Optical Astronomy Observatories (WIYN) telescope being built on Kitt Peak in Arizona. The average imperfection in the surface of the WIYN mirror rises less than 16 nanometers, or less than a thirtieth of the wavelength of green light. If the mirror were as big as the United States, the average blemish would be only two centimeters.

Figuring, which comes after polishing, also has improved. Instead of using abrasives to shape the final figure of the mirror, a new process called ion figuring uses a beam of electrically charged atoms to bump atoms off the surface of the mirror. Ion figuring can achieve a nearly perfect surface, something that takes a skilled optician countless days to do by hand.

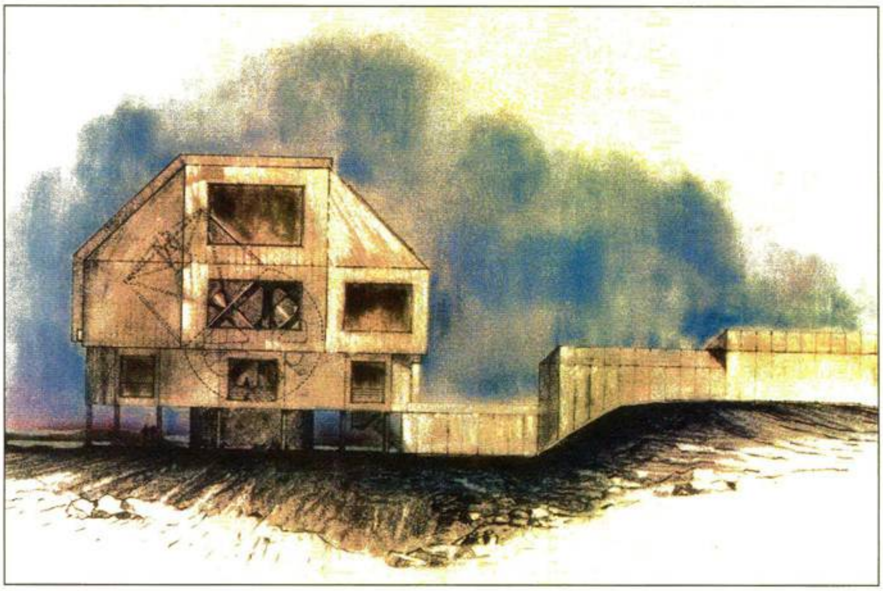
Technology though is just one side to this astronomical revolution. Astronomers have started to think differently about their telescopes, designing them to do specific tasks instead of requiring them to be general-purpose instruments as they were in the past. Two good examples are the Sloan Digital Sky Survey and the Spectroscopic Survey Telescope. By restricting the types of instruments needed or the types of objects being observed, astronomers can reduce the cost of a telescope significantly.

But it still takes money — lots of it — to build a large telescope. Several decades ago, the federal government was a major benefactor of new observatories. The costs today are high and the government can no

Magellan

The Magellan telescope, a project of the University of Arizona and the Carnegie Institution of Washington, will reside at Carnegie's Las Campanas Observatory in Chile. It will use a 6.5-meter spuncast mirror from the University of Arizona mirror lab, the next to be cast after the MMT mirror. The altazimuth mount uses a novel wheel support instead of a fork for greater stiffness so wind won't disturb the pointing of the scope. The strong but lightweight design enables the telescope to weigh less than one-tenth of a similarly sized Hale telescope.

To maintain the site's good seeing, the telescope enclosure will have heavy insulation and air conditioning. The octagonal dome structure is open below the observing floor so air at ground level passes under the telescope rather than over it. A separate building will house all heat-producing equipment and form the center for astronomers' activities. Workers presently are breaking ground for the telescope. Magellan's astronomers hope for first light in 1996.

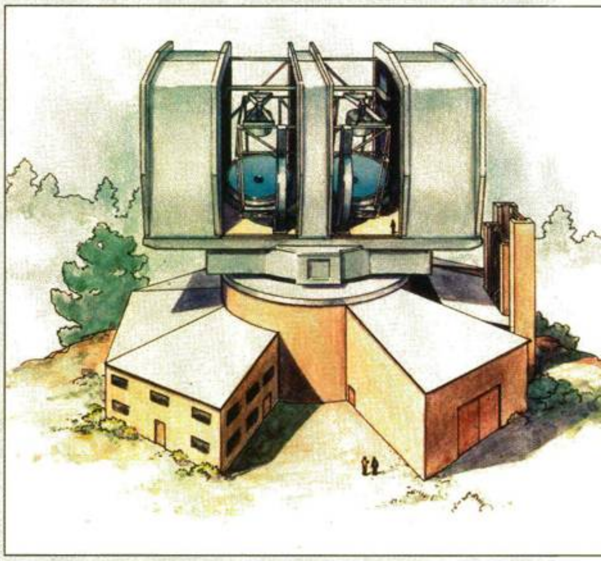


Observatories of the Carnegie Institution of Washington

Large Binocular Telescope

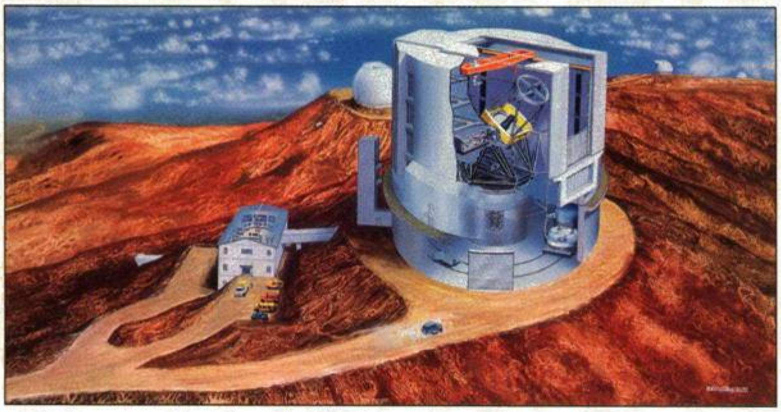
The Large Binocular Telescope consists of two 8.4-meter f/1.1 mirrors mounted side by side. Formerly the Columbus Project, this is a project of the University of Arizona and Italy's Arcetri Astrophysical Observatory, and funded in part by the Research Corporation in Tucson. With the two mirrors working in concert, the light-gathering power will equal that of a 12-meter telescope and the resolving power that of a 23-meter telescope. The telescope will stand on Mount Graham, a location that has aroused environmental concerns because it is the home of the endangered Mount Graham red squirrel. Astronomers have moved the proposed site for the scope to an area that retains good astronomical conditions but one the U. S. Forest Service considers a poor habitat for the squirrels.

Current plans call for putting only one of the two mirrors in the telescope but building the full telescope structure so the second mirror can be added in the future. The 8.4-meter mirror could be spuncast in the University of Arizona mirror lab as early as 1994. That same year should also see the start of construction for the telescope, with a projected completion in 1997.



University of Arizona

Japan's National Large Telescope

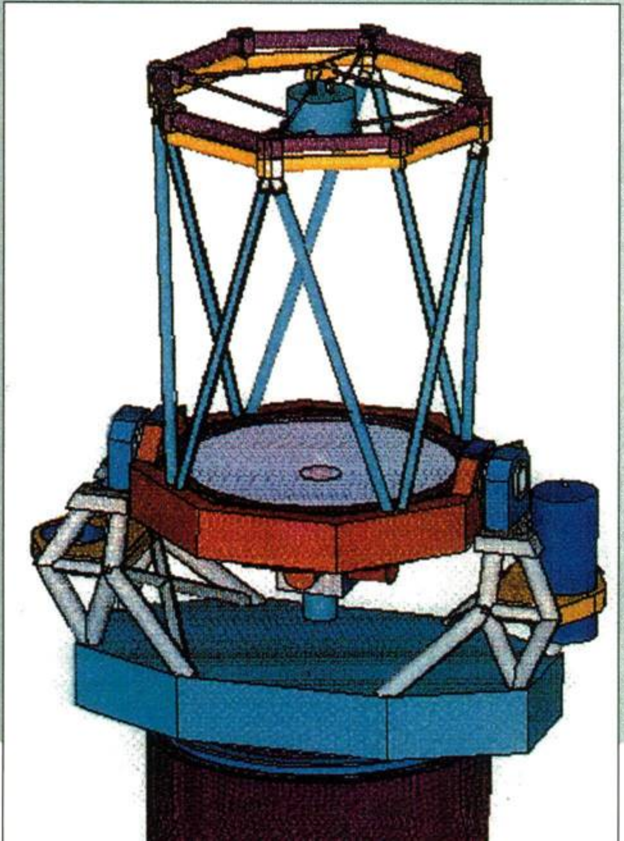


National Astronomical Observatory of Japan

Joining the Keck telescopes on Mauna Kea will be Subaru, an 8.2-meter visible-light and infrared telescope built by the National Astronomical Observatory of Japan. Subaru is the Japanese word for the Pleiades, but the name derives from an older word meaning "to tie together," which emphasizes the international character of astronomical research. The mirror, cast by Corning, will be only 20 centimeters thick. To maintain its shape, a system of over 250 sensors and actuators will deform the mirror to maintain high-quality images. Like the Magellan telescope, the control building will be separate from the cylindrical telescope enclosure to isolate heat sources that might ruin image quality. Construction started in 1992 and Corning has begun work on the mirror. After the three years needed to cast the mirror, it will take another three years to polish and figure the mirror. First light should occur in 1999.

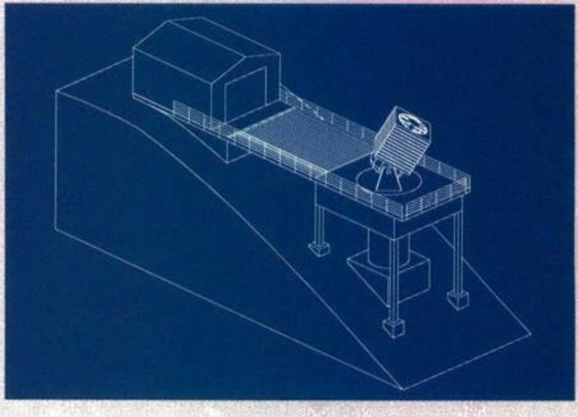
Gemini — Twin Telescopes

Gemini is a project of the United States (50 percent), the United Kingdom (25 percent), Canada (15 percent), Chile (5 percent), Argentina (2.5 percent), and Brazil (2.5 percent). These nations are building two 8-meter scopes, the first on Mauna Kea and the other on Cerro Pachón, six miles southeast of Cerro Tololo in Chile. The scopes will work in both visible light and the infrared, permitting imaging down to 0.1 arcsecond over a wide 45-arcminute field. As with the 8-meter mirror for Subaru, Corning will cast the one-piece mirrors for this project. Although the primary mirrors will be fast (f/1.8), astronomers plan to use the scopes at f/16 — and perhaps f/6 if sufficient funds remain available after the construction of the scopes to build the extra secondary mirror assembly. The telescope enclosure and control building isolate sources of heat to maintain image quality, like the Magellan and Subaru scopes. Although it is still in the design phase, the present schedule calls for first light for the Mauna Kea scope in 1998 and for the Cerro Pachón scope in 2000.



Gemini Telescope Project, AURA

One Sky to Go, Please



Apache Point Observatory

While astronomers have designed most big scopes to handle a broad range of observing projects from stars to distant galaxies and quasars, a few new scopes are being built with one specific project in mind. One such telescope is the Sloan Digital Sky Survey telescope being built by the University of Chicago, the Institute for Advanced Study, and Fermi National Accelerator Laboratory, with financial assistance from the Alfred P. Sloan Foundation. While its planned 2.5-meter aperture is tiny as compared with the other projects described in this article, the Sloan telescope's mission is huge.

As the telescope slowly moves across the sky on its alt-azimuth mount, an array of charge-coupled devices (CCDs) at the telescope's focus will electronically image the sky in 2.5°-wide strips to fainter than 23rd magnitude in four different colors. It will take the scope about a year to cover the northern sky. Computers will automatically search the electronic survey data for galaxies and quasars. Using the newly determined positions of these objects, the telescope will then automatically take the spectra and measure the motions of more than 1 million galaxies and 100,000 quasars, sometimes taking as many as 600 spectra at once. The astronomers expect to publish the survey data on CD-ROMs for use by professional and amateur astronomers.

Workers have broken ground for the scope at Apache Point Observatory in New Mexico, run by the Astrophysical Research Consortium. One feature of the scope that all backyard astronomers will recognize is the roll-off building. Airflow directly over the telescope will keep the telescope at air temperature and eliminate air turbulence in the dome, thus reducing the effects of atmospheric blurring of images.

longer provide the funds needed for these initiatives. Thankfully some friends of astronomy have contributed substantial funds to continue the exploration of the universe.

This isn't a new tradition. Andrew Carnegie, James Lick, Percival Lowell, Leander McCormick, John D. Rockefeller, Charles Yerkes, and others made possible many of the world's most famous observatories. Today the Research Corporation, a non-profit organization that supports research in colleges and universities, and the Arnold D. Frese, W. M. Keck, and Alfred P. Sloan foundations are helping to convert astronomers' dreams into reality. Astronomers from around the world are also joining together to build telescopes that individually would be too expensive for their countries.

While new technology has made mammoth telescopes possible, it has also made mid-sized scopes (about 4 meters in diameter) more affordable. These workhorses will still make many important discoveries even after the 8-meter scopes go to work. The 3.5-meter WIYN telescope mentioned before will become Kitt Peak's second-largest telescope. The building is already finished, with the telescope and control systems scheduled for completion later this year. The University of North Carolina and Columbia University are building a 4-meter telescope on Cerro Pachón in Chile, the site of one of the 8-meter Gemini telescopes. The National Optical Astronomy Observatories will operate the scope (the Southern Observatory for Astrophysical Research) and split the observing time with the two universities.

Another mid-sized project is the 4-meter Cambridge-Cambridge telescope planned by the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, and Cambridge University in England. This instrument will measure the redshifts of faint galaxies from the Southern Hemisphere. The Frese Foundation of New York donated part of the cost of this scope.

Astronomy has a bright future with the unparalleled construction of a dozen giant scopes. Not since the construction of the 5-meter Hale telescope has so much anticipation been in the air. What will this new generation of telescopes discover as they look deeper into the universe than ever before? ☐

Robert Bunge is a free-lance writer living in Bowie, Maryland, and a frequent contributor to ASTRONOMY.

Rainbows in the Sky

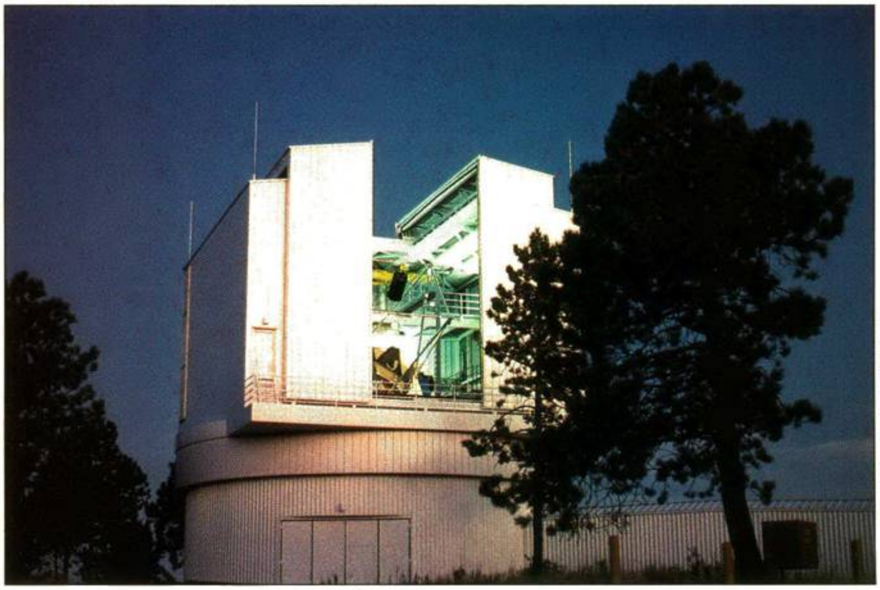
Another telescope with a specific goal is the Spectroscopic Survey Telescope being developed by Pennsylvania State University and the University of Texas. Although the telescope is capable of narrow-field imaging, astronomers will primarily use it for spectroscopy. Instead of a one-piece mirror, this telescope uses 85 one-meter spherical mirrors, creating an effective aperture of 8 meters. Like the Arecibo radio telescope, the telescope itself will not move, saving lots of money through the elimination of the drive and a movable mount. A primary focus module will hold corrector lenses for imaging and optical fibers to link the telescope to spectrometers. Earth's rotation will carry objects through the telescope's field of view with tracking during short exposures provided by the movable primary focus module. The telescope will join other scopes at McDonald Observatory near Fort Davis, Texas.

University of Texas, Austin

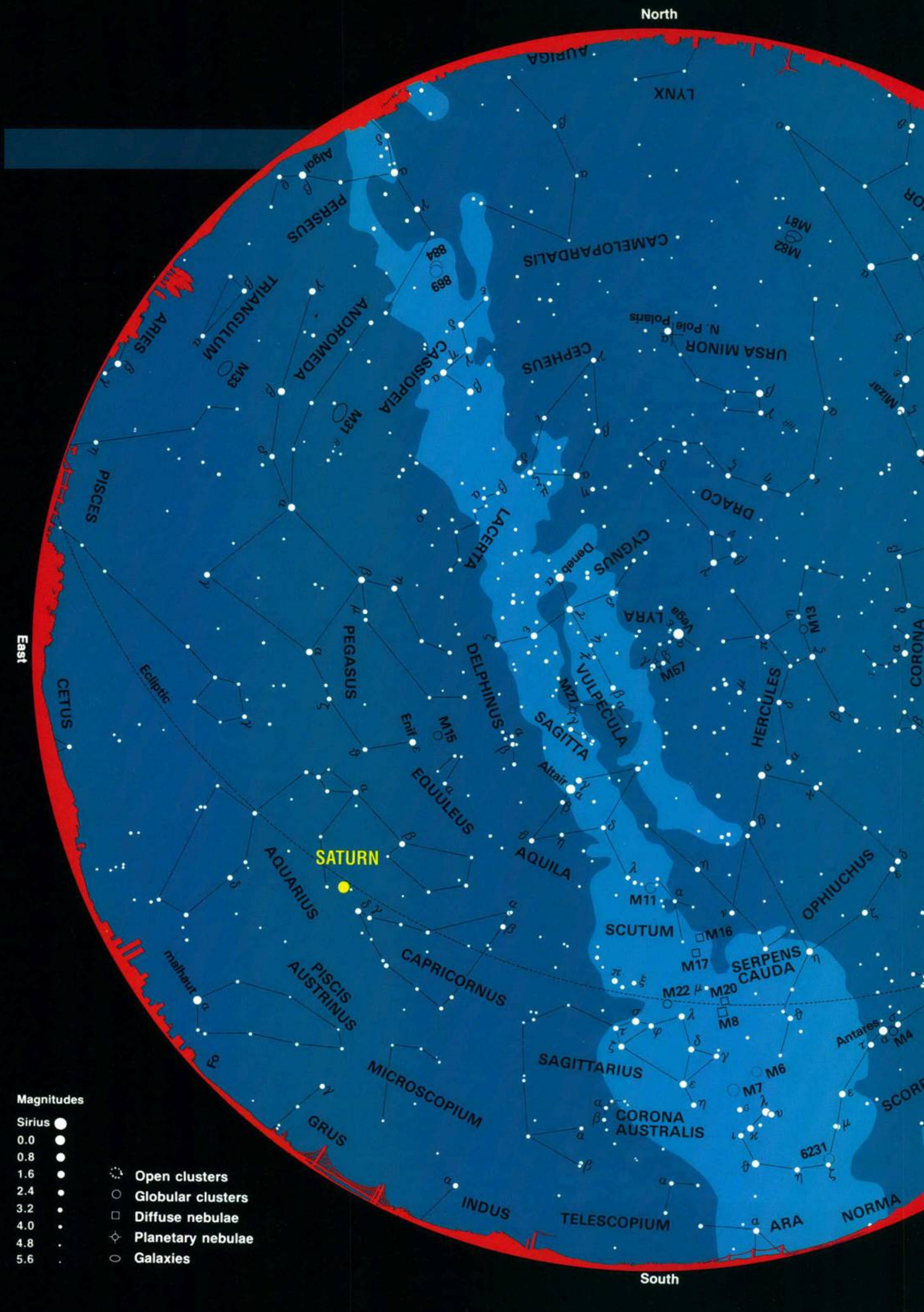
Observing from Home

Large aperture is not the only innovation in new telescopes. Remote observing is fast becoming another asset in astronomers' bag of tricks. A bane of astronomers is the scheduling of large telescopes. Observers may have three nights on a large scope and not receive any more observing time until the next year. When astronomers travel to an observatory, their time is wasted and productivity decreases if the weather is cloudy or otherwise not suitable for observing. If a supernova goes off or a transient object appears, it is often difficult to reschedule observers and equipment, leading to a missed observing opportunity.

One group that has licked this problem is the Astrophysical Research Consortium, which runs Apache Point Observatory in New Mexico. Their 3.5-meter telescope contains a spuncast mirror made by the University of Arizona mirror lab and installed earlier this year. Astronomers observe from their home institution — or even home — over a computer network. Each night can be divided among several observers because no one has to travel to the observatory. If weather conditions prevent imaging by one observer, another astronomer with a spectroscopy program can quickly take over, preventing the waste of valuable observing time. This technology soon will become standard on other large scopes as astronomers strive to maximize observing time.



Dan Long, University of Chicago


North
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M33
M31
CASSIOPEIA
CEPHEUS
N. Pole Polaris
URSA MINOR
Mizar
PISCES
LACERTA
DRACO
CYGNUS
Deneb
LYRA
Vega
M57
M13
HERCULES
CORONA
PEGASUS
DELPHINUS
VULPECULA
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SAGITTA
CETUS
Ecliptic
Enif
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SERPENS CAUDA
CAPRICORNUS
PISCIS AUSTRINUS
Fomalhaut
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M20
M8
Antares
M4
SAGITTARIUS
M6
M7
MICROSCOPIUM
CORONA AUSTRALIS
GRUS
6231
INDUS
TELESCOPIUM
ARA
NORMA
SCORPIUS
Magnitudes
Sirius
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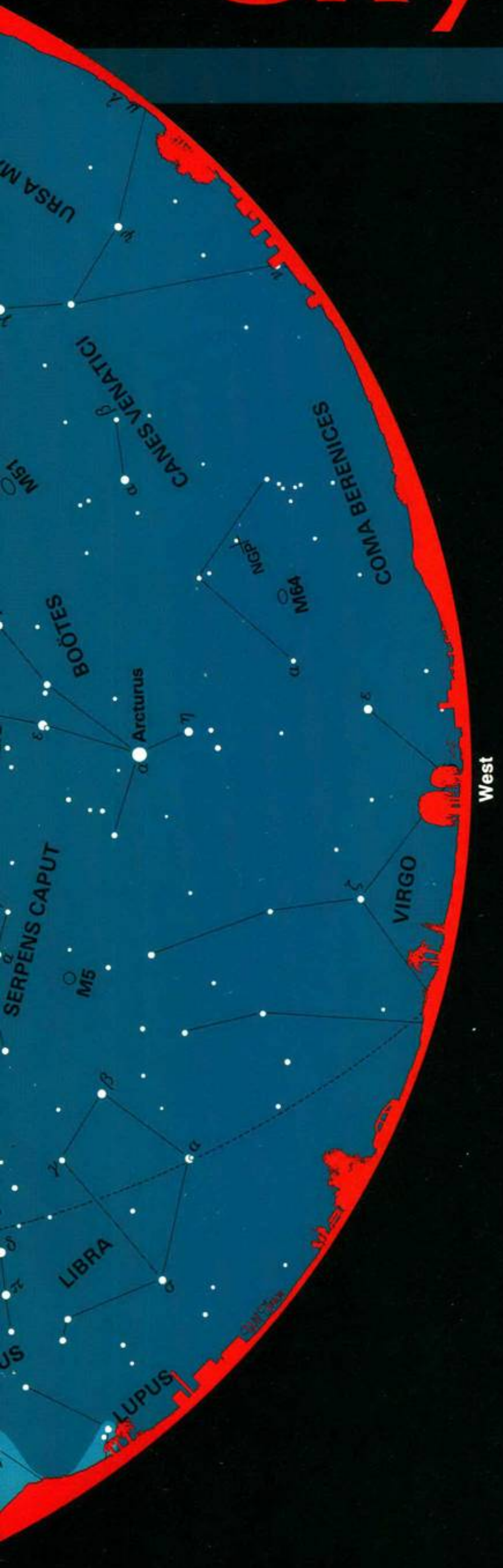
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

August 1993



SATURN AT ITS BEST

Saturn reaches opposition on August 19, making this the best month to observe the ringed planet. To the naked eye, Saturn appears as a 0.3-magnitude point of golden light against the background stars of Aquarius. Through a telescope, Saturn appears larger than at any other time this year: Its disk measures 19" across and its rings span 43".

PERSEIDS PEAK ON AUGUST 12

The balmy nights of August invariably draw backyard observers to view the annual Perseid meteor shower. But this year's shower may hold a special treat — a display of historic proportions. The shower's parent comet, Comet Swift-Tuttle, returned to the inner solar system last year and presumably replenished the stock of meteor-causing dust particles in its orbit.

MERCURY BRIGHT BEFORE DAWN

The innermost planet climbs into the morning twilight glow in early August, becoming visible low in the east-northeast about half an hour before sunrise. Your best chance to spot Mercury comes around August 4, when it reaches greatest elongation and shines at magnitude 0.1 below and to the left of brilliant Venus.

Calendar of Events

2	Full Moon is at 8:10 a.m. EDT
3	Mercury is at greatest western elongation (19°)
	The Moon passes 7° north of Saturn, midnight EDT
5	Mercury passes 8° south of Pollux, 10 p.m. EDT
6	Pluto is stationary
	The Moon is at apogee (251,815 miles from Earth), 11:58 p.m. EDT
10	Last Quarter Moon is at 11:19 a.m. EDT
12	Perseid meteor shower peaks
14	The Moon passes 2° south of Venus, 10 p.m. EDT
17	New Moon is at 3:28 p.m. EDT
19	The Moon is at perigee (223,935 miles from Earth), 2:53 a.m. EDT
	Saturn is at opposition
20	The Moon passes 5° south of Mars, noon EDT
	The Moon passes 6° south of Jupiter, midnight EDT
22	Venus passes 7° south of Pollux, 7 p.m. EDT
24	First Quarter Moon is at 5:57 a.m. EDT
	Pallas is at opposition
27	Vesta is at opposition
29	Mercury is in superior conjunction
31	The Moon passes 7° north of Saturn, 2 a.m. EDT
	Full Moon is at 10:33 p.m. EDT

Map Art by Wil Tirion

by Deborah Byrd

Stephen Keene

SATURN SHINES BRIGHTLY in the southeast late on August evenings, nestled between Aquarius and Capricornus. With binoculars held steady, you can make out the elongated shape of Saturn's rings.

SATURN PROMINENT ALL NIGHT

The most distant of the bright planets, Saturn, reaches opposition on August 19. That's when Earth passes between Saturn and the Sun and lies closer to the ringed planet than at any other time during the year. Saturn appears opposite the Sun in our sky at opposition, rising at sunset and spending the whole night above the horizon.

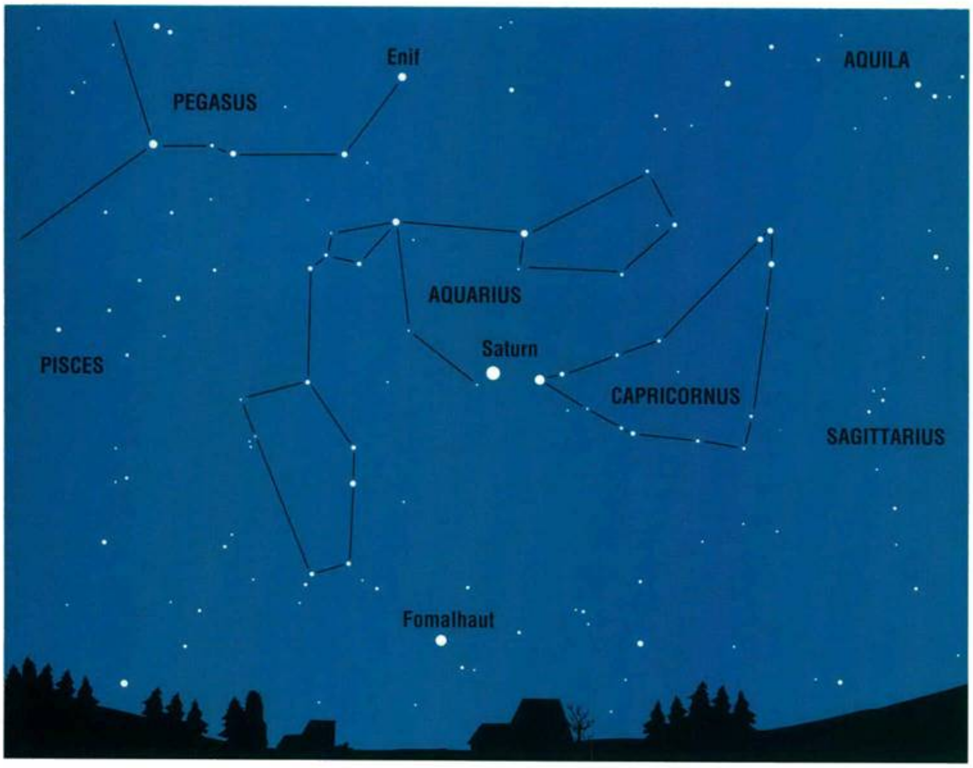
You'll recognize Saturn for its golden color and quiet beauty. Because we now are closest to it, Saturn shines most brightly for the year, at magnitude 0.3. It lies in the constellation Aquarius, just east of the arrowhead pattern of Capricornus.

Saturn appears slightly fainter now than it did at last year's opposition despite being several million miles closer to us. If you have been peering at this planet through a telescope over the past year, you know why. Saturn's encircling rings appear less open this year than last, and the rings provide most of Saturn's brightness. The rings will continue closing down over the next two years, appearing edge-on to Earth in 1995.

You need a telescope to see the rings of Saturn clearly. But a good pair of binoculars held steadily will show the planet as elongated. If you notice a night when the air is so still that even the stars don't twinkle much, look for this elongation and the gap between the planet's disk and rings.

Binoculars can also show you Saturn's largest and brightest moon, Titan. The best time to look is when the 8th-magnitude satellite lies as far from the glow of Saturn as possible. On August 6 and 22, Titan is as far west of Saturn as it will be all month. On August 13 and 29, Titan lies farthest east. At these greatest western and eastern elongations, the satellite lies about 4.5 ring diameters from the planet, or about half the field of view in 7x50 binoculars.

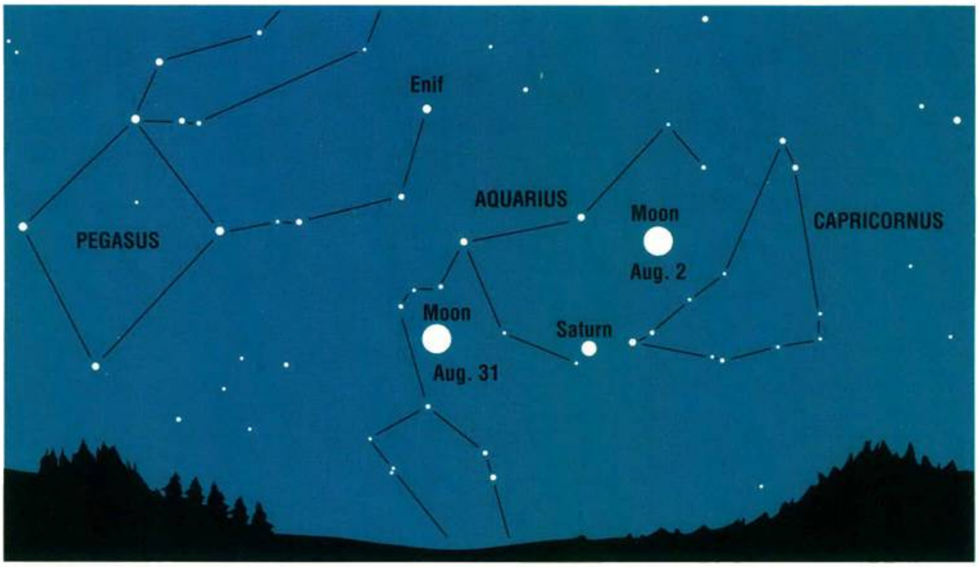
You can see Saturn near Earth's Moon twice this month. Both times the Moon is nearly Full, because it too is then opposite the Sun from Earth. The Moon passes Saturn on the night of August 3/4 and again on August 30/31.



ONCE IN A BLUE MOON

Speaking of the Moon, it is Full twice this month as seen from the Americas — on the morning of August 2 and on the evening of August 31. (Europe and Asia experience two Full Moons next month.) All the Full Moons have names. The Full Moon of August is traditionally called the Green Corn Moon or Grain Moon. According to a more recent tradition of unknown origin, when two Full Moons fall in the same month, the second one is called a blue Moon.

These blue-in-name-only Moons get a lot of attention. They call to mind the phrase "once in a blue Moon," which indicates something special and rare. But they aren't really rare. They come along seven times every nineteen years — or about once every two-and-a-half to three years. Nor are these Moons really blue. When you see the Full Moon on August 31, it will appear as ordinary as any Full Moon can, shedding bright moonlight, casting shadows over the landscape, and obliterating the fainter stars.



A BLUE MOON IN AUGUST means two Full Moons occur during the month. The Full Moon of August 2 rises among the stars of northern Capricornus, while the second, the Blue Moon of August 31, appears against the background of Aquarius.

THE PERSEIDS OF THE CENTURY?

As August begins, the Perseid meteor shower is building slowly toward what could be an historic peak on the morning of August 12. The reasons for the high expectations are the return last year of Comet Swift-Tuttle, the parent comet of the Perseid meteor shower, and the high number of meteors seen during last year's shower. To get all the details on what to expect from the Perseids this year, see "Gearing Up for the Perseids" on page 76.

AUGUST'S PLANETS

August offers bright planets all night long. As evening twilight begins to fade, the first planet to come into view is **Jupiter**. Though Jupiter appears noticeably fainter than it did near the peak of its apparition last spring, at magnitude –1.8 it is easily the brightest point of light in the evening sky.

Jupiter lies among the stars of Virgo, not far from that constellation's brightest star, 1st-magnitude Spica. Another visitor in Virgo this month is **Mars**, but the Red Planet is far fainter than Jupiter and fainter even than Spica. Look for ruddy Mars low in the western twilight sky, below and to the right of Jupiter. It shines at magnitude 1.7, relatively faint because it is now far across the solar system from Earth. The bright star above and to the right of Mars is Denebola, the tail of the Lion in Leo.

Mars lies just over 15° from Jupiter when August begins. The two edge closer together throughout the month and will pass within a degree of one another in early September.

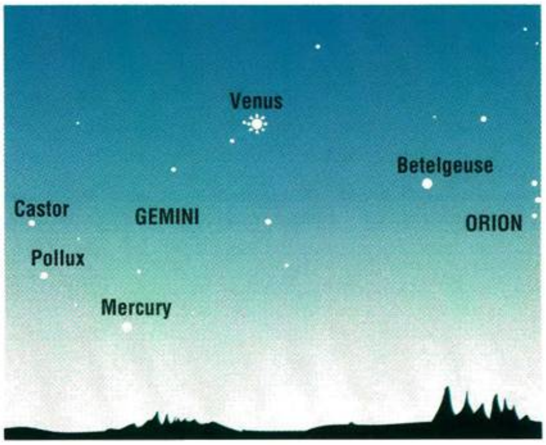
As the month passes, Jupiter, Mars, Spica, and Denebola all sink closer to the Sun's glare. Watch them on the evening of August 20, when the young crescent Moon reappears in the western sky. It spends a few evenings passing the planets and stars in the twilight.

The brightest planet, **Venus**, rises about three hours before the Sun in August. The steep angle of the ecliptic — the apparent path of the Sun, Moon, and planets across the sky — helps Venus appear high in the predawn sky. Although Venus has faded somewhat over the past few months, it still shines brilliantly at magnitude –4.0. It outshines even the bright "winter" stars that are now coming into view in this part of the sky.

Venus is now moving ahead of Earth in its smaller orbit around the Sun, but it will be several more months before it disappears from view. This planet will remain in our sky throughout the coming autumn.

Likewise, **Mercury** is moving ahead of Earth in its orbit. But it races around the Sun in only 88 days, much faster than Earth or Venus, which is why Mercury comes and goes from our sky very quickly. Mercury reaches greatest western elongation — its greatest apparent distance from the Sun — on August 3/4. It then lies 19° west of the Sun and can be seen low in the east-northeast before dawn, below and to the left of

MERCURY JOINS VENUS in the predawn sky in early August. At greatest elongation on August 4, Mercury lies 10° high in the east-northeast 30 minutes before the Sun rises.



Venus. Mercury never gets high in the sky — on the morning of the 4th, it lies 10° above the horizon 30 minutes before sunrise.

At greatest elongation, Mercury shines at magnitude 0.1. Two stars low in the morning twilight might help you pick it out from among the many bright stars in this part of the sky. Castor and Pollux, the brightest stars in the constellation Gemini, lie just above Mercury before dawn. Mercury passes 8° south of Pollux on the morning of August 6. For a few days afterward, Castor and Pollux seem to point to Mercury.

THE STARRY SKY

Saturn comes to opposition this year at the western edge of the constellation Aquarius the Water Carrier. The planet and constellation both come up around sunset and remain in the sky nearly all night.

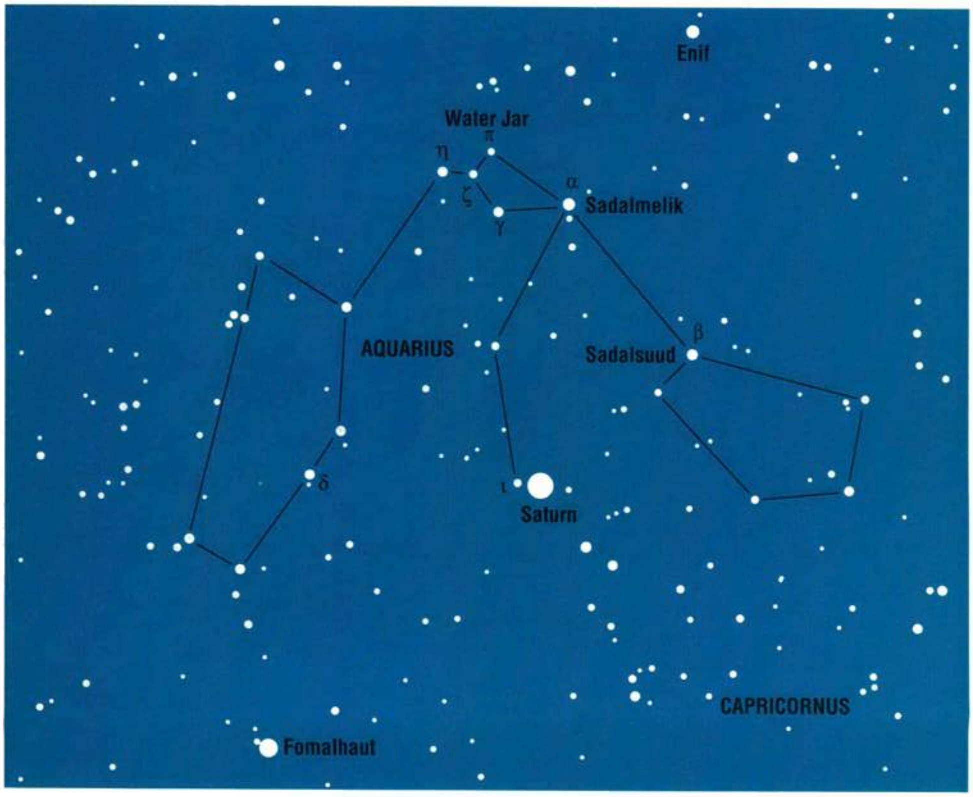
Aquarius is a large, rambling star grouping, with no stars brighter than magnitude 2.9. Sky watchers in many cultures have seen this figure as a man pouring water from a jar. If you view this constellation in a dark sky, you may see why. The most distinctive feature in Aquarius is an asterism shaped like a sideways letter Y. This pattern of stars is known as the Water Jar, and this month it lies about 15° northeast of Saturn.

The Water Jar consists of Gamma (γ), Eta (η), and Pi (π) Aquarii, with a fourth star — Zeta (ζ) — at their center. You can find it by drawing an imaginary line from Enif, the nose of the Flying Horse Pegasus, to Fomalhaut, the brightest star in the constellation Piscis Austrinus, the Southern Fish. This line nearly runs through the Water Jar. Then look for a faint zigzag line of stars running from the Water Jar to Fomalhaut. The ancient Babylonians saw these stars as water from the jar of Aquarius trickling into the open mouth of the Southern Fish. If your sky is dark enough — and your imagination active enough — you might see this, too.

Also look for the star Iota (ι) Aquarii, which lies just east of Saturn. Although it shines at only 4th magnitude, it's famous because the planet Neptune was discovered near it on September 23, 1846.

The two brightest stars in Aquarius are called Sadalmelik, meaning "the lucky one of the king," and Sadalsuud, meaning "the luckiest of the lucky." Needless to say, these stars once were considered to bring good fortune. The Sun used to be located in Aquarius during the rainy season in ancient Mesopotamia. The region of the heavens around Aquarius was known to Mesopotamians as the Sea and to the early Greeks as the Water. This association with water led to the creation of many "watery" constellations in addition to Aquarius, including Capricornus the Sea Goat, Piscis Austrinus the Southern Fish, and Cetus the Whale. ☐

AQUARIUS THE WATER CARRIER plays host to Saturn this year, but during any year you can see the constellation's famous "Water Jar" asterism — from which water supposedly trickles toward Fomalhaut.



Deborah Byrd writes and produces the daily "Earth and Sky" radio series. It now can be heard on over 240 stations.

MAGNIFICENT SATURN

Gérard Therin

The ringed planet appears opposite the Sun in our sky on August 19, making it the top target in backyard telescopes this month. Saturn remains visible all night long at opposition, rising approximately at sunset, crossing the meridian around midnight, and setting just as the Sun rises.

Actually, anytime Saturn is in the sky is a good time to view it. But opposition is best because Saturn then lies closest to Earth and thus appears largest in a telescope's eyepiece. The large disk (measuring 18.8" across with the rings spanning 42.9") means you can see the planet's details at their best. And with Saturn high in the south during the middle of the night, you should enjoy steady seeing because Earth will have given off most of the heat it absorbed during the day.

As you should do when observing any object, begin observing Saturn at low power. This gives you the highest possible contrast. Then slowly increase the power until you see no improvement in the image quality. Drop back one step from there to get your optimum power for the seeing conditions that night.

Most of the superlatives used to describe Saturn refer to the rings, and rightly so. They are one of the most exquisite sights in our solar system. In my opinion, the rings are exceeded only by the pearly white solar corona seen during a total eclipse and by great comets, neither of which we see regularly.

I could fill this column extolling the virtues of Saturn's rings — discussing the dark Cassini division, which separates the outer A ring from the brighter, inner B ring, and the barely discernible, innermost C ring. Instead, I want to entice you into observing the belts and zones of Saturn's cloudtops. Although they aren't as flashy as the rings, the belts and zones are well worth viewing.

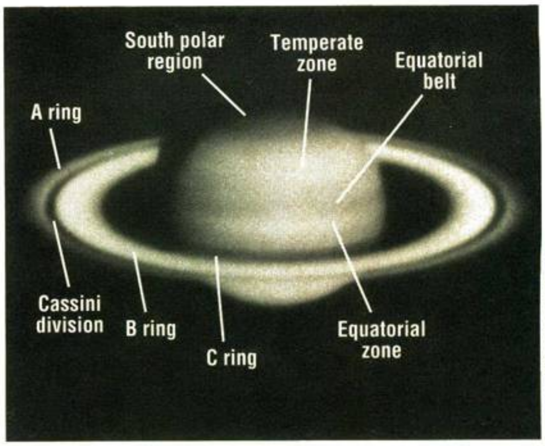
Compared with the contrasty features visible in Jupiter's cloudtops, those on Saturn are considerably more subtle. That's because Saturn is much colder than Jupiter. It's colder for two reasons. First, Saturn lies almost twice as far from the Sun as Jupiter so it receives only about 30 percent as much heat from that source as Jupiter does. Second, Saturn contains only 30 percent as much mass as Jupiter. This has prevented it from generating as much internal heat as Jupiter.

Whereas Jupiter provides us with browns, tans, oranges, reds, and whites, the predominant colors on Saturn's disk are white, cream, gray, and gold. The gold color is so distinctive that even with my naked eye, I can recognize Saturn anywhere in the sky.

Saturn's disk offers two prominent equatorial belts separated by a broad zone. Although the equatorial zone usually appears cream-colored, it can be nearly pure white. This is the zone where the brilliant white spot appeared in September 1990. Other white spots appear occasionally, so it's worth checking this area of Saturn's disk carefully.

If the seeing is particularly steady, you also might see a very thin, irregular band that neatly bisects the equatorial zone. But don't be

SATURN DESERVES YOUR ATTENTION as it reaches opposition this month. How much of the subtle detail on the planet's disk and in the planet's rings can you see? (Photo above shows Saturn as it appeared last year; photo below shows Saturn in 1969, when its south pole tipped toward Earth.)

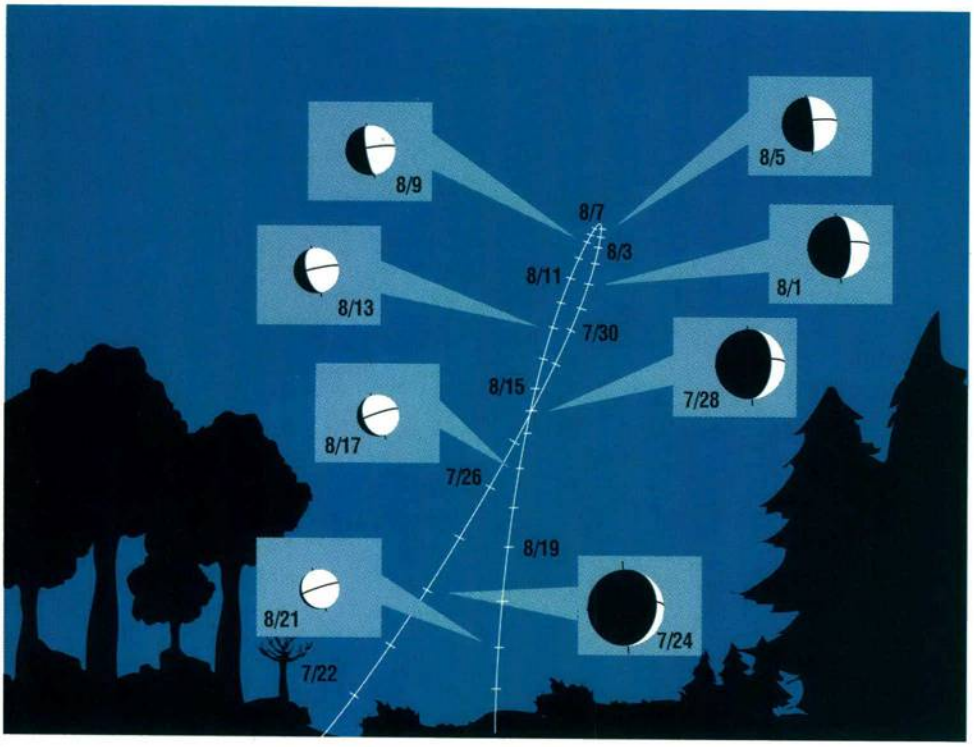


Lunar and Planetary Laboratory

disappointed if you can't spot this gray to light brown band — I've seen it only a half-dozen times in 35 years of observing Saturn.

Several fainter belts and zones girdle Saturn's disk between the bright equatorial belts and the polar regions. You'll need a night of good seeing and a telescope with an aperture of 6 inches or more to see these fainter belts. A light-blue filter will also help. I use an Ednalite Chrome Blue 80 that I found at a garage sale for 25 cents. Other planetary observers recommend a Wratten #80A or 82A.

Speaking of blue, that's the color many people assign to Saturn's polar regions. Others see it as gun-metal gray. An orange filter will enhance your view of these regions by making them considerably darker. Try a Wratten 21 (orange) or 23A (light red). This year Saturn's north polar region tilts toward Earth.



MERCURY'S EXCELLENT APPARITION in the morning sky during late July and early August offers many chances to follow the planet's changing telescopic appearance. All disk diagrams show south at top.

A PAIR OF MORNING PLANETS

For those of you who get up early or stay up all night, Mercury makes a good appearance in early August. It reaches greatest elongation on August 3/4, when it lies 19° west of the Sun. Fortunately for observers in the Northern Hemisphere, the ecliptic makes a fairly steep angle to the eastern horizon at this time of year, so most of that 19° translates into altitude above the horizon. For an observer at 40° north latitude, Mercury lies 10° above the east-northeastern horizon 30 minutes before sunrise.

If you begin observing Mercury with your telescope in late July, you can watch the planet's phase go from a slim crescent through "half-moon" to gibbous in the space of a few weeks. On July 28, Mercury appears 9.2" across and 19 percent lit, while it shines at magnitude 1.4. At greatest elongation on the morning of August 4, the planet displays a 7.5"-diameter disk that is 41 percent lit and glows at magnitude 0.1. As the apparition starts to wind down around August 15, Mercury appears only 5.8" in apparent diameter but is 80 percent lit, so it shines brightly at magnitude –1.1.

Venus also lies in the morning sky, but it is higher and brighter than Mercury and therefore much easier to see. On August 15, a telescope will reveal the –4.0-magnitude planet as a 14.0"-diameter disk that is 77 percent lit.

Compare the pure white of Venus' cloud-covered disk with the pale yellow of Mercury's disk. The clouds on Venus reflect the Sun's light without changing the color, so this planet appears white. But Mercury's cratered surface scatters the shorter wavelengths of sunlight more effectively than the longer wavelengths, so blue light is removed and we see Mercury as yellowish. (The fact that we typically view Mercury low in the twilight sky also helps remove the blue.)

TELESCOPIC PLANETS

You can find **Mars** low in the west just after the Sun sets. Its disk mea-

COORDINATES FOR IDA

Date	R.A. (2000)	Dec.
Aug. 6	12h42.1m	–5°30'
Aug. 7	12h43.3m	–5°37'
Aug. 8	12h44.5m	–5°45'
Aug. 9	12h45.7m	–5°52'
Aug. 10	12h46.9m	–6°00'
Aug. 11	12h48.1m	–6°07'
Aug. 12	12h49.3m	–6°15'
Aug. 13	12h50.6m	–6°23'

sures a bit more than 4" across this month and it shines at only magnitude 1.7. Finding it is moderately challenging. Observing it is nearly fruitless — about all you can hope to see with a disk this small is the north polar cap, which now tips toward Earth.

Jupiter lies a bit higher in the western sky after sunset than Mars does, and is certainly worth a good look. The –1.8-magnitude planet measures 33" across, more than big enough to show intricate cloudtop details. Point your telescope toward Jupiter soon after sunset — if you wait too long the giant planet will sink into the horizon haze.

Uranus and **Neptune** remain near each other in northeastern Sagittarius throughout August. Blue-green Uranus measures 3.7" across this month and shines at magnitude 5.6, while blue-gray Neptune appears 2.3" across and glows at magnitude 7.9.

ASTEROIDS IN THE EYEPIECE

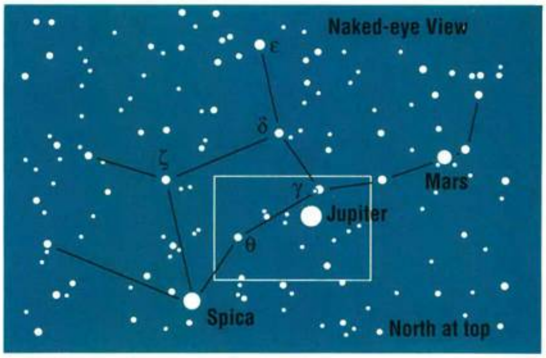
Two of the "Big Four" asteroids reach opposition this month. On August 24/25, **2 Pallas** lies opposite the Sun in our sky and shines at magnitude 9.1. Three days later, **4 Vesta** reaches opposition and appears fully 3 magnitudes brighter than Pallas. In fact, at magnitude 5.9 it's bright enough to spot with the naked eye from a dark observing site. See "A Double Dose of Asteroids" on page 74 for details on how to find these two bright minor planets.

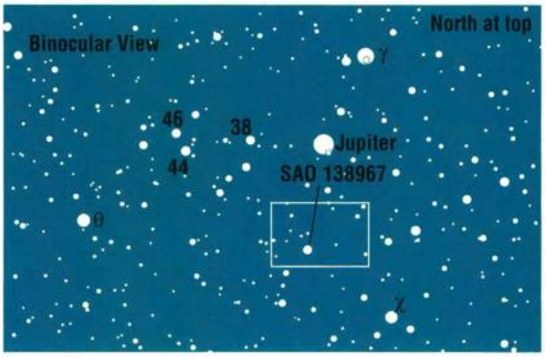
Ordinarily, I don't suggest searching for an asteroid glowing dimly at 15th magnitude. After all, brighter and more interesting targets usually abound. But I'm making an exception in the case of **243 Ida**. The reason? This month Ida becomes the second asteroid to receive a visit from the Galileo spacecraft as it heads toward its 1995 encounter with Jupiter.

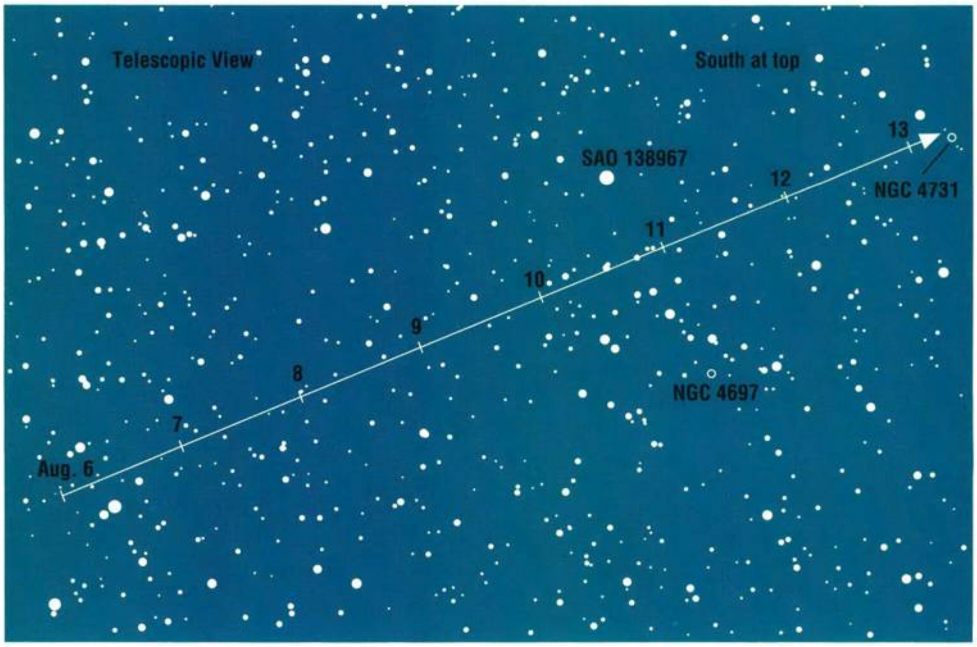
You'll need a 10-inch or larger telescope and dark, steady skies to find Ida. If you don't have high-quality skies, you'll need considerably more aperture. Use the finder charts at right to find Ida's field in Virgo. Then either photograph the field or, using a medium- to high-power eyepiece to darken the background and limit the field, plot the positions of all the stars you see on one night. Return to the same field a night or two later and sketch the stars again. The one that moves is Ida. (By the way, don't bother to look for the intrepid Galileo. It's more than a few magnitudes fainter than Ida!)

What will Galileo find as it passes Ida? Will the asteroid resemble 951 Gaspra, which Galileo encountered in 1991? Or will it be a contact-double asteroid like 2143 Toutatis, as radar observations revealed late last year? Until Galileo returns its precious images, we're just guessing. But you can watch Ida this month and wonder. □

Rick Shaffer is an engineer and writer in the aerospace industry in Southern California.

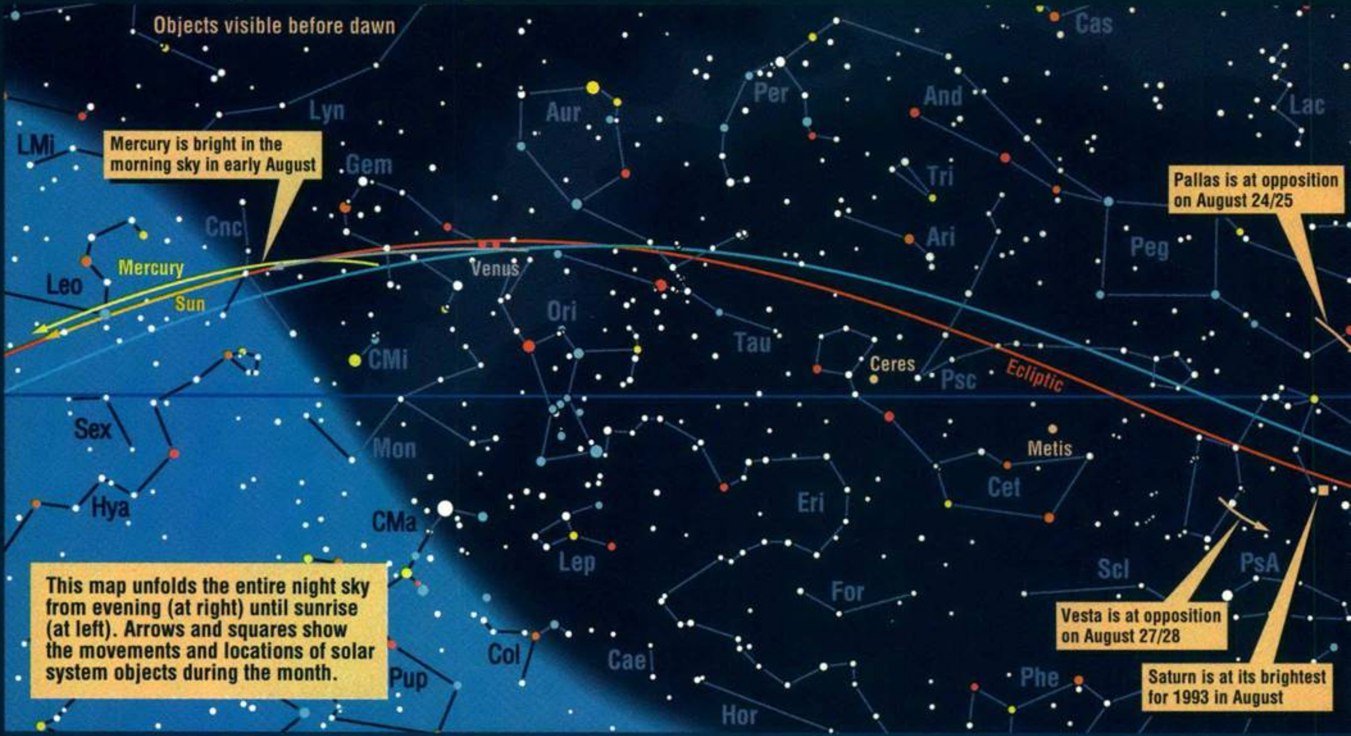






ASTEROID 243 IDA receives a visit from the Galileo spacecraft this month. These finder charts will help you get a pre-encounter view of the faint asteroid. Positions are shown for 11 p.m. EDT (10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT).

The Solar System August 1993


Objects visible before dawn
Cas
Lyn
Aur
Per
And
Lac
LMi
Gem
Tri
Cnc
Ari
Peg
Leo
Mercury
Sun
Venus
Ori
Tau
Ceres
Psc
Ecliptic
CMi
Sex
Mon
Metis
Cet
Hya
CMa
Eri
Lep
Scl
PsA
For
Col
Cae
Pup
Phe
Hor

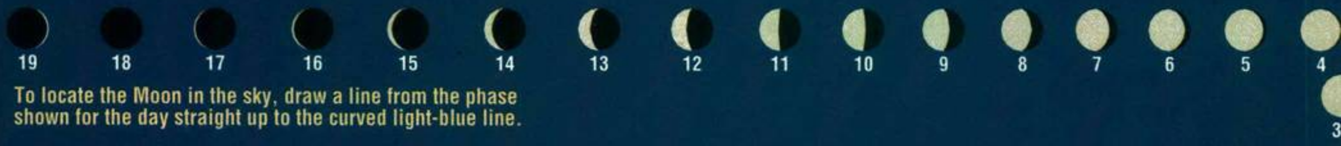
Mercury is bright in the morning sky in early August

Pallas is at opposition on August 24/25

Vesta is at opposition on August 27/28

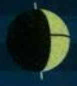
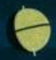
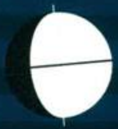
Saturn is at its brightest for 1993 in August

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3

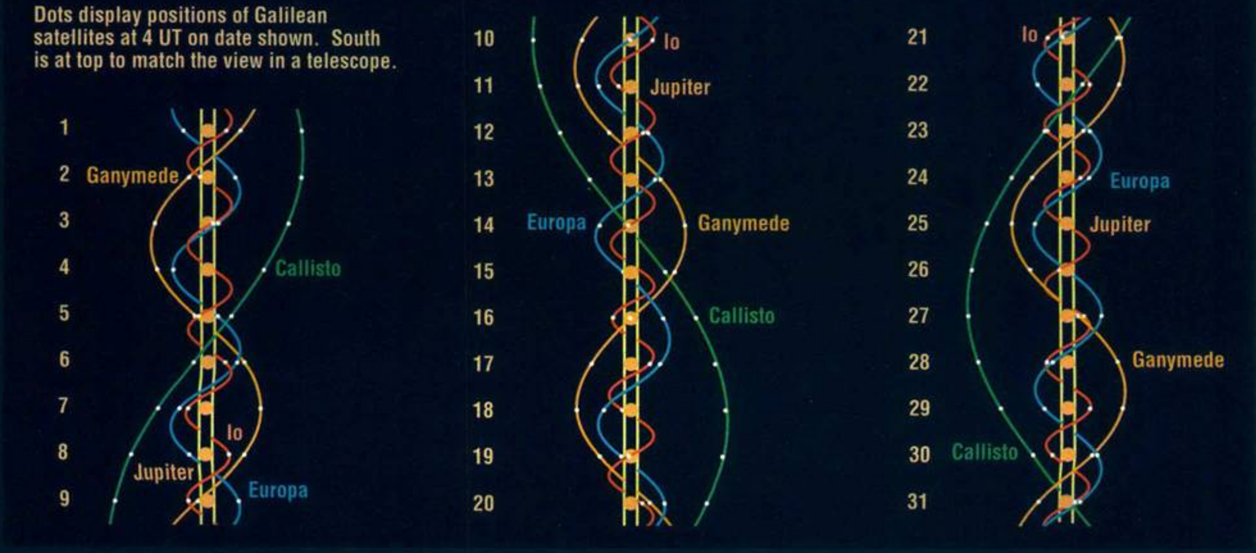
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

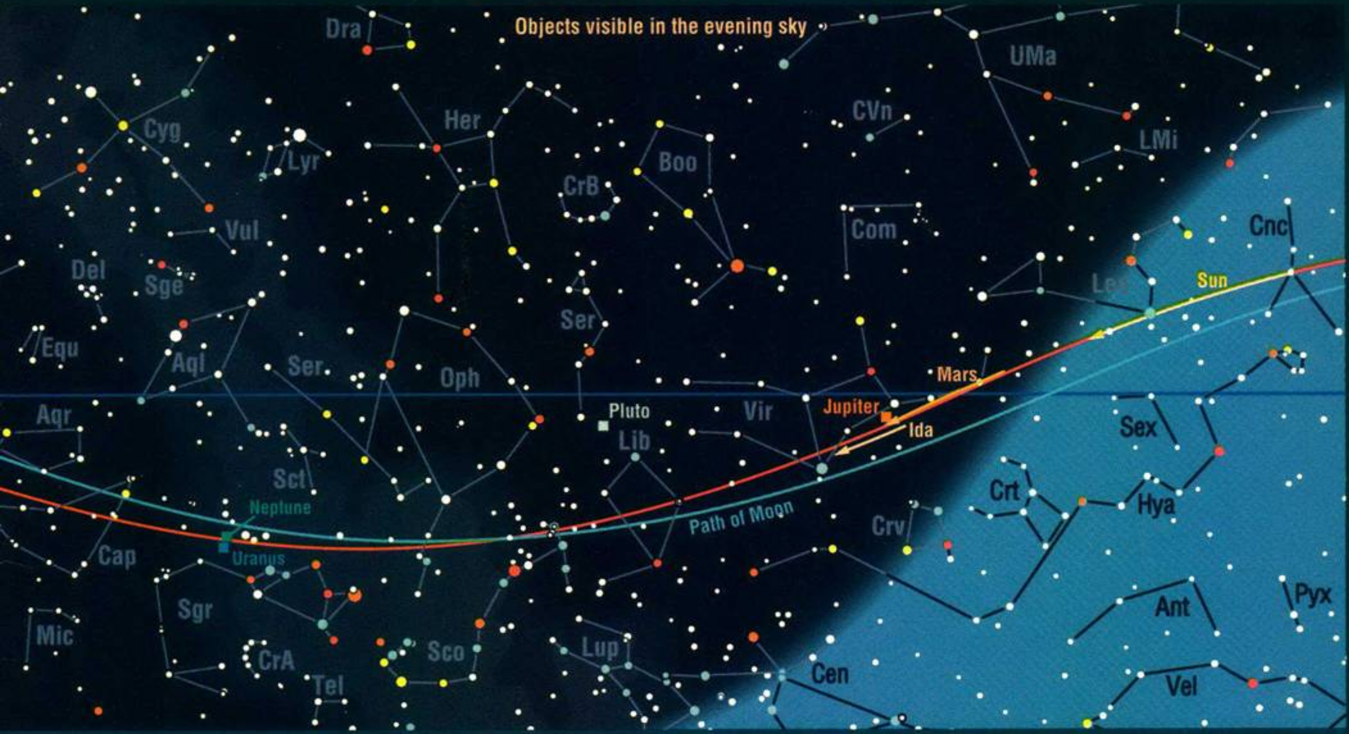
PLANETS	MERCURY	MERCURY	VENUS	MARS
Date	August 1	August 15	August 15	August 15
Magnitude	0.7	–1.1	–4.0	1.7
Angular Size	8.3"	5.8"	14.0"	4.2"
Illumination	29%	79%	77%	96%
Distance (AU) from Earth	0.811	1.160	1.194	2.251
Distance (AU) from Sun	0.361	0.308	0.723	1.608
Right Ascension (2000.0)	7h25.6m	8h42.5m	7h05.4m	12h08.0m
Declination (2000.0)	19°28'	19°02'	21°35'	–0°17'

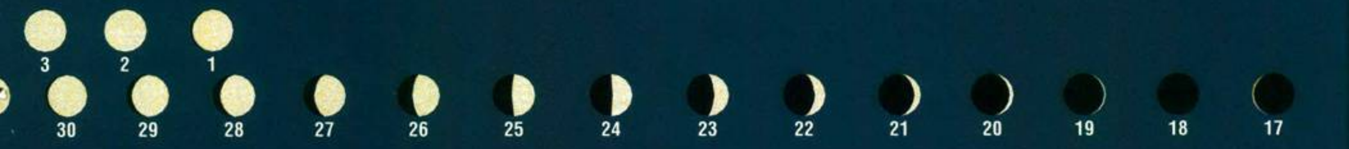




Jupiter's Moons

Dots display positions of Galilean satellites at 4 UT on date shown. South is at top to match the view in a telescope.




Objects visible in the evening sky
Dra
UMa
Cyg
Lyr
Her
CVn
LMi
Boo
CrB
Vul
Com
Cnc
Del
Sge
Leo
Sun
Equ
Aql
Ser
Ser
Oph
Mars
Jupiter
Aqr
Pluto
Lib
Vir
Ida
Sex
Sct
Neptune
Crt
Hya
Uranus
Path of Moon
Crv
Cap
Sgr
Ant
Pyx
Mic
CrA
Sco
Lup
Tel
Cen
Vel


3
2
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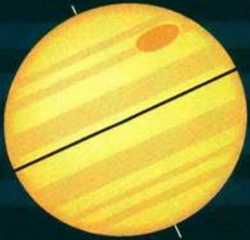
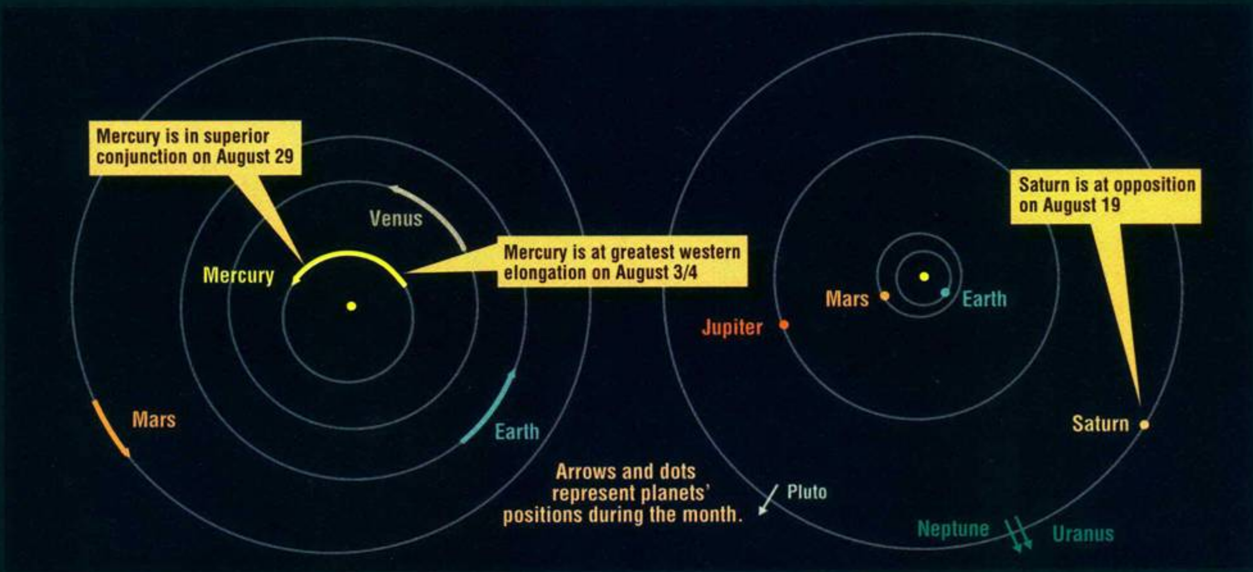
17



JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
August 15	August 15	August 15	August 15	August 15
–1.8	0.4	5.6	7.9	13.7
32.5"	18.8"	3.7"	2.3"	0.1"
99%	100%	100%	100%	100%
6.051	8.804	18.755	29.332	29.717
5.453	9.813	19.610	30.184	29.744
12h46.4m	22h00.6m	19h22.8m	19h21.8m	15h36.1m
–3°43'	–13°48'	–22°34'	–21°26'	–4°40'

The Planets in Their Orbits


Mercury is in superior conjunction on August 29
Venus
Mercury
Mercury is at greatest western elongation on August 3/4
Mars
Earth
Saturn is at opposition on August 19
Mars
Earth
Jupiter
Saturn
Pluto
Neptune
Uranus

Arrows and dots represent planets' positions during the month.

Celestial Sights of the Future

R. Nolthenius

ASTRONOMY looks forward to the sky's best events of the coming decades.

by Alan Dyer and Richard Talcott

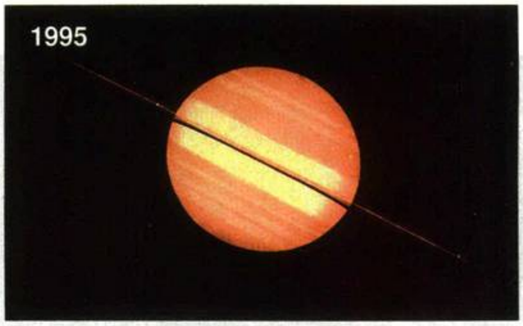
Eclipses, conjunctions, transits, and more. Between 1994 and 2017, the year of the next total eclipse of the Sun visible from continental North America, a host of spectacular celestial events await observers. For our look ahead we've selected what we think will be the best the sky has to offer in the coming years. Two or more planets will meet many times — we've picked only the closest conjunctions involving the brighter planets. And we've selected only those lunar occultations visible from the Western Hemisphere and involving the brightest planets. While several bright comets may grace the skies in the next few years, all will be unpredictable visitors that will appear with only a few weeks' warning. (Events in bold are visible from North America.)

1994

May 10	Annular eclipse of the Sun (North America)
November 3	Total eclipse of the Sun (South America)

1995

All year	Saturn's rings edge-on
May 27	Dawn-into-morning occultation of Venus by waning crescent Moon (Europe)
October 24	Total eclipse of the Sun (Southeast Asia, Indonesia)
November 17	Evening conjunction of Venus, Mars, and Jupiter including close approach of Venus and Mars on Nov. 22



Richard Proctor

Every 13 to 16 years, the rings of Saturn are oriented edge-on to our line of sight. Through a small telescope they disappear. But through a large telescope you can still see them as a razor thin line of light. It's a wonderful opportunity to see Saturn as you rarely have before.

1996

February 22	Spectacular sunset occultation of Venus by waxing crescent Moon (Hawaii, Pacific)
April 3/4	Total eclipse of the Moon (eastern North America, South America, Europe, Africa)
September 26/27	Total eclipse of the Moon (North and South America, Europe, Africa)

1997

March 9	Total eclipse of the Sun (Russia)
March 24	Deep partial eclipse of the Moon (North and South America)
September 16	Total eclipse of the Moon (Australia, Asia, Africa)
September 18	Dawn occultation of Saturn by waning gibbous Moon (Hawaii, North and Central America)
December 9	Midnight occultation of Saturn by waxing gibbous Moon (North America)

1998

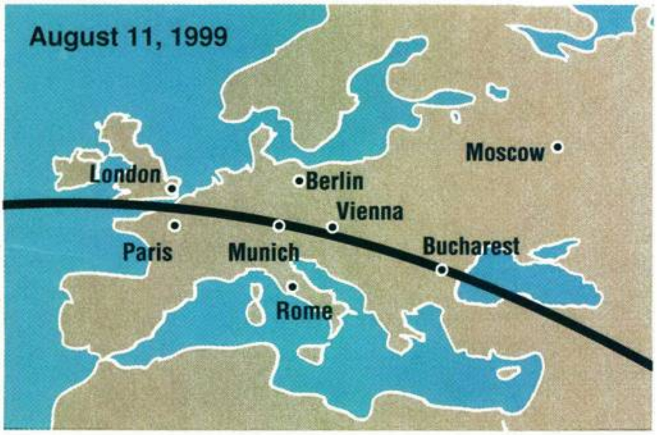
February 26	Total eclipse of the Sun (Galapagos, South America, Caribbean)
April 23	Close conjunction of Venus and Jupiter near waning crescent Moon
April 23	Very rare double occultation of Venus and Jupiter by Moon (South Atlantic)
August 22	Annular eclipse of the Sun (Indonesia, South Pacific)
September 19	Dawn occultation of Venus by waning crescent Moon (Hawaii, Pacific). Close conjunction elsewhere.

1999

February 16	Annular eclipse of the Sun (central Australia)
February 23	Close conjunction of Venus and Jupiter
August 11	Total eclipse of the Sun (England, Europe, Middle East, India)
November 15	Grazing transit of Mercury (North America, eastern Pacific)
November 17	Leonid meteor storm ???

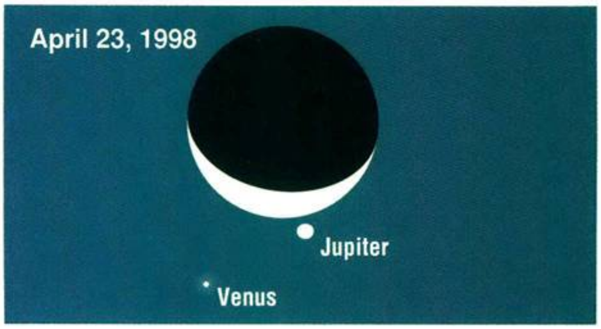
2000

January 20/21	Total eclipse of the Moon (North and South America, Western Europe)
April 12	Evening conjunction of Mars, Jupiter, and Saturn in Aries
July 16	Total eclipse of the Moon (Japan, Australia, Pacific, Hawaii)
August 1	Spectacular sunset occultation of Venus by waxing crescent Moon (southwestern North America)
December 25	Christmas Day partial eclipse of the Sun (North America)

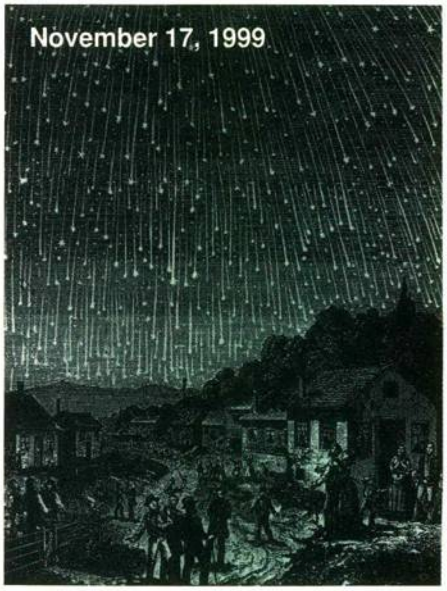


ASTRONOMY: all diagrams by Thomas L Hunt

Before the end of the century, eclipse fans in the Western Hemisphere have two South American eclipses to look forward to: November 3, 1994, and February 26, 1998. But the eclipse likely to be seen by the most people in the near future occurs on August 11, 1999, when the Moon's shadow races across Europe, bringing up to two minutes of darkness at midday for tens of millions of people.



On April 23, the waning crescent Moon will occult both Venus and Jupiter at the same time, the only time this century that such an event can be seen. Unfortunately, the event will be visible in its entirety only from the South Atlantic. From eastern Brazil, observers will see the two planets emerge from behind the Moon shortly after moonrise. From West Africa, the Moon misses Venus but occults Jupiter. From western Europe, the Moon misses both planets, but the tight cluster will be spectacular in the predawn sky. By the time the trio rise for North American observers, the Moon will have moved 2° to 3° away from Venus and Jupiter.



Department of Library Services, American Museum of Natural History

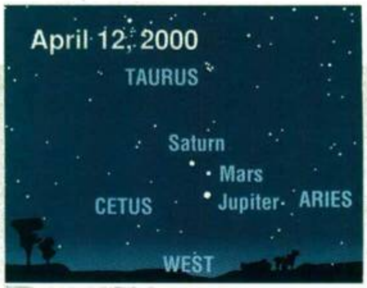
During a rare "meteor storm" hundreds of meteors per second pour down from the shower's radiant point. The annual Leonid meteor shower sometimes puts on such a once-in-a-lifetime show. The last was in 1966. Other storms occurred in 1799, 1833, and 1866, giving the great Leonid storms a 33- or 34-year cycle. No storm occurred in 1899 or 1933, and there's no guarantee one will in 1999. But everyone will be watching just in case.

2001

January 9	Total eclipse of the Moon (Asia, Europe, Africa)
June 21	Total eclipse of the Sun (southern Africa)
December 14	Annular eclipse of the Sun (near Hawaii, Pacific, Central America)

2002

May 5	Evening conjunction of Venus, Mars, and Jupiter
May 10	Close approach of Venus and Mars
June 10	Near-total annular eclipse of the Sun (Pacific, north of Hawaii)
December 4	Total eclipse of the Sun (southern Africa)



In the spring of the last year of the millennium, Mars, Jupiter, and Saturn cluster together low in the evening sky in the constellation Aries. There are many conjunctions of planets in the next few years, but this one is bound to generate a great deal of interest because of its similarity to a famous conjunction which occurred in the spring of 6 B.C.

2003

May 7	Transit of Mercury (Europe, Africa, Asia)
May 15/16	Total eclipse of the Moon (North and South America)
August 27	Very close approach of Mars
November 8/9	Total eclipse of the Moon (eastern North America, South America, Europe, Africa)

August 27, 2003

Donald C. Parker

Mars comes especially close to Earth once every 15 or 17 years. The Red Planet then appears as large as it ever gets through a telescope. Our last close look was in September 1988. The next close approach comes 15 years later, in August 2003. Mars is then 56 million kilometers away, closer than it's been in over 1,000 years and providing the finest views until August 2287.

2004

May 4	Total eclipse of the Moon (Asia, Africa)
June 8	Transit of Venus (eastern North America, Europe, Africa, Asia, Australia)
October 27/28	Total eclipse of the Moon (N. and S. America, Europe)
November 4	Close conjunction of Venus and Jupiter

2005

April 8	Annular/total eclipse of the Sun (Pacific, Central America)
October 3	Annular eclipse of the Sun (Spain, Africa)

2006

March 29	Total eclipse of the Sun (Africa, Turkey, Russia)
June 17	Close conjunction of Mars and Saturn
November 8	Transit of Mercury (North and South America)

2007

March 3	Total eclipse of the Moon (Europe, Africa)
August 28	Total eclipse of the Moon (western North America, Pacific, New Zealand)

2008

February 1	Close conjunction of Venus and Jupiter
February 20/21	Total eclipse of the Moon (North and South America, Western Europe)
July 10	Close conjunction of Mars and Saturn
August 1	Total eclipse of the Sun (High Arctic islands of Canada, Russia)
August 16	Deep partial eclipse of the Moon (Asia, Africa, Europe)

2009

April 22	Dawn occultation of Venus by waning crescent Moon (western North America)
July 22	Total eclipse of the Sun (China, Pacific)
All year	Saturn's rings edge-on

2010

July 11	Total eclipse of the Sun (South Pacific)
August 5	Evening conjunction of Venus, Mars, and Saturn
December 21	Total eclipse of the Moon (North and Central America)

2011

May 11	Close conjunction of Venus and Jupiter
June 15	Total eclipse of the Moon (Asia, Africa)
December 10	Total eclipse of the Moon (western North America, Pacific, Australia, Asia)

2012

May 20	Annular eclipse of the Sun (Japan, Pacific, western United States)
June 5	Transit of Venus (North America, Pacific, Asia, Australia)
November 13	Total eclipse of the Sun (south Pacific)

2013

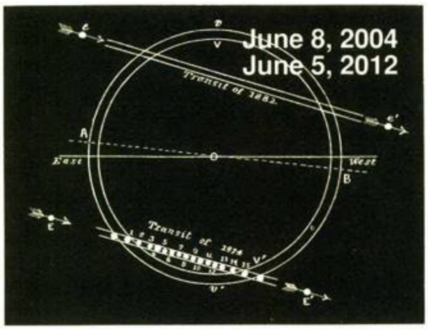
May 10	Annular eclipse of the Sun (Australia, South Pacific)
November 3	Annular/total eclipse of the Sun (Atlantic, Africa)

2014

April 15	Total eclipse of the Moon (North and South America)
August 18	Close conjunction of Venus and Jupiter
October 8	Total eclipse of the Moon (western North America, Pacific, New Zealand)

2015

February 21	Close conjunction of Venus and Mars
March 20	Total eclipse of the Sun (North Atlantic, North Sea, North Pole)
April 4	Total eclipse of the Moon (western North America, Pacific, New Zealand, Australia)
July 1	Close conjunction of Venus and Jupiter
September 27/28	Total eclipse of the Moon (eastern North America, South America, Western Europe, Africa)
October 22	Morning conjunction of Venus, Mars, and Jupiter



Richard Proctor

Transits of Venus are the stuff of legends. No more than twice each century, Venus passes directly between Earth and the Sun, appearing as a fuzzy black spot on the face of the Sun. Transits of Venus occur in pairs eight years apart which themselves are separated by either 113 or 130 years. The last set was in 1874 and 1882. The next will be in 2004 and 2012. The June 8, 2004 transit is visible from eastern North America, Europe, Africa, Asia, and Australia. The June 5, 2012 transit can be seen from Asia, Australia, and North America.

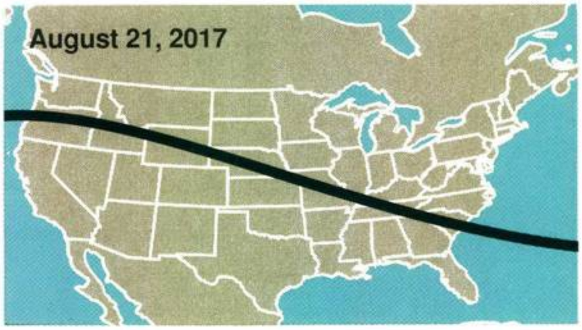
2016

March 9	Total eclipse of the Sun (Indonesia, Pacific)
August 27	Very close conjunction of Venus and Jupiter
September 1	Annular eclipse of the Sun (central Africa)

2017

February 26	Annular eclipse of the Sun (South America, South Atlantic, Africa)
August 21	Total eclipse of the Sun (United States)

Where will you be in 1999? or 2004? or 2017? No matter what else the next decades bring, we can be certain they offer a wonderful array of eclipses, rare transits, and beautiful gatherings of planets in the twilight sky. The sky always gives us something to look forward to. ☐



After a long wait since July 1991, the umbral shadow of the Moon finally touches the North American continent again. On August 21, the lunar shadow sweeps across the center of the United States creating a total eclipse and one of the most eagerly anticipated astronomical events of the next 25 years.

Since 1975

America's #1 Source For Telescopes, Binoculars & Accessories

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From Hwy 280 take Cupertino exit, south 1.5 miles on DeAnza, from Los Gatos take Hwy 9 to Saratoga-Sunnyvale Rd.
408/255-8770

Monterey Bay–Santa Cruz
2450 17th Ave., West Marine Building.
From Hwy 1, take Soquel Drive exit, 1/2 block from the freeway at Soquel Avenue
408/464-0465

Some prices in retail stores may vary.

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Packed with a huge selection of quality telescopes, binoculars and accessories, all at low discount prices! Hundreds of exclusive items you won't find anywhere else.

Only a small selection of our products are in this ad! Be sure you have our catalog.

CELESTRON

Telescopes, Binoculars and Accessories —

See Catalog For Our Full Selection.

Orion is the #1 source for Celestron products! Our low, low prices can really save you a bundle! Whether you are considering a big telescope or a small one, or a binocular or accessory, chances are Orion has just what you are looking for. Celestron telescopes are available with a variety of mounts, including German-style equatorial or fork mounts, with a wide range of available drive systems.

A huge selection of models, in all price ranges, available for immediate delivery!

Schmidt-Cassegrains — Celestron pioneered these fantastic instruments, and has an enviable reputation for building unsurpassed, exquisitely fine Schmidt-Cassegrain optical systems.

Refractors — Celestron's high-performance refractors are superb all-purpose telescopes, for astronomical or terrestrial observing. Built to standards that far exceed other telescopes in their class.

Reflectors — Celestron's popular reflector telescopes feature superior optical performance and full-featured, precision equatorial mounts which permit a full complement of optional accessories including electronic drive systems.

TeleVista II 60mm Refractor

Equally at home viewing the rings of Saturn or boats across the bay. Quality 25mm (28x) 1.25"eyepiece, all metal optical tube and yoke mount, finder scope, adjustable tripod, diagonal prism.

#9075 **$199** (8.97)

Sky Explorer II 60mm Refractor

Ideal for lunar and planetary study, plus it's a powerful terrestrial telescope. 900mm f.l, 6x30 finder; star diagonal ; two eyepieces, equatorial mount; setting circles; tripod; and lighted accessory tray.

#9076 **$329** (13.22)

SpaceProbe II 4.5" Reflector

Great 4.5" f/8 reflector, ideal for planetary and deep space. Equatorial mount, slow motion controls, setting circles. 6x30 finder plus 25mm (36x) and 9mm (100x) 1.25" eyepieces. Deluxe tripod.

#9078 **$388** (22.19)

Sky Explorer II 80mm Refractor

Perfect for planetary and lunar observation. Bigger equatorial mount than competitive models, two 1.25" eyepieces, 6x30 finder, star diagonal, deluxe tripod and accessory tray. #9077 **$488** (32.66)

New! Orion 6", 8", 10", & 12.5" Dobsonian Telescopes

SPECIAL INTRODUCTORY PRICES!

#9901 **$299** 6" f/8
#9903 **$549** 10" f/5.6
#9902 **$399** 8" f/6
#9904 **$699** 12.5" f/4.8

Prices include precision helical focuser and 25mm Sirius Plossl eyepiece — an $87 value!

These prices are not a misprint! Ideal for both beginners and advanced astronomers, these great new scopes offer high performance and lasting value. Precision 1/8-wave accurate reflector optical systems are ideal for both planetary and deep space observation. Image quality rivals scopes selling for four times their price. Huge light grasp for superb images of faint celestial subjects. See the Great Nebula in Orion in incredible detail. Get lost in the cloud belts of Jupiter. Lunar craters so detailed, you'll think you're in orbit!

Precision Dobsonian-type mounts are the finest in their class. Teflon zero-backlash bearings make it a breeze to track objects without wobble or vibration. Much more stable than comparable equatorial scopes. Lightweight, rugged, easy to transport and set up. Complete instruction manual.

Built to last a lifetime. Primary and secondary mirrors are aluminized and SiO overcoated for durability. Cabinet-quality laminate finish resists dirt and moisture.

Packing & UPS Shipping to any address in the 48 states: 6"—$39. 8"—$49 10" & 12.5" — call for charges.

DEEP SPACE EXPLORER
Incredible Value!

Shown with optional finder scopes

The 6" model is the ideal beginner's or family scope - and is incredibly low-priced. Weighing only 29 lbs. complete, it's easily moved or handled by anyone. The 8" model offers 77% more light grasp, but is still a reasonable 39 lbs. and is only slightly larger.

The 10" and 12.5" models are perfect for those who can observe from darker sky locations. While heavier and larger than the smaller models at 68 and 85 lbs., they offer tremendous performance for their low prices.

MONEY BACK 100% SATISFACTION GUARANTEE
If you are not completely satisfied with your purchase from Orion, for any reason,
Just return it in new condition within 30 days after delivery for a full refund.

CALL TOLL-FREE 800-447-1001
IN CALIFORNIA: 800-443-1001

Huge Selection of Astronomy Binoculars

New! 50mm Orion Observer™ II Binoculars - 7x, 10x, & 12x

Fine quality, moderately priced binoculars, excellent for both astronomy and daytime observation. Fully coated optics, unique hand strap for a secure and comfortable grip.

7x50 #9643 **$89.50** (4.44)
10x50 WA #9644 **$94.50** (4.44)
12x50 WA #9645 **$94.50** (4.44)

50mm Explorer™ Binoculars

Our newest high performance binoculars with BAK-4 prisms and Multi-Coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design.

7x50 #9306 **$117** (4.44)
10x50 #9308 **$127** (4.44)

50mm Adlerblick Binoculars

Incredible wide field eyepiece design, Fully Multi-Coated, BAK-4 prisms, and best special glass objective lenses make the 7x50 Adlerblick the arch rival of European brand binoculars selling for 3-4 times the price. Orion buys direct, saving you money. Includes deluxe hard case, lens caps and straps.

7x50 #9612, *10x50* #9610 **$287** (5.28)

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7 x 35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Standard Model #9504 **$147** (4.71)
Rubber Armored Model #9627 **$157** (5.07)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501, *14X70* #9594 **$299** (6.97)

80mm FMC Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable.

#9502 **$379** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended.

#9496 **$389** (8.05)

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required.

#9498 **$399** (8.05)

10x70 Military-Spec Binoculars

Light enough to hand hold, yet powerful enough to bring in remarkable views of deep space celestial objects. With military-grade optics, for the highest degree of optical accuracy and mechanical ruggedness. Will last through a lifetime of use, even under the most extreme environmental conditions. Absolutely waterproof and fogproof. With built-in folding rubber objective lens shades/dew caps. Includes deluxe case, photo tripod adapter. 7mm exit pupil. 5° field of view.

#9309 **$444** (7.29)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495, *25x100* #9497 **$888** (29.00)
Shipped by FedEx only.

Observing Aids

NEW! Eyepiece/Accessory Cases

With patented unbreakable latches, die-cut foam inserts.
Inside Dimensions shown

11"x7"x3" #5951 **$17.95** (2.78)
12.5"x9"x5" #5952 **$26.95** (3.36)
16"x11"x5" #5953 **$46.95** (5.19)

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers —fit all Meade & Celestron 8" SCs
DC #3503, AC #3504 **$44.95** (2.98)

10" Dew Zappers—fit all Meade 10" SCs
DC #3506, AC #3508 **$49.95** (2.98)

12V DC Dew Gun.—#5601 **$19.95** (2.78)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 **$39.95** (2.98)

Other sizes available for scopes 3.5" to 14"—See our catalog for details

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.

8"Model
#15130 **$33.95** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43)

Ask about other sizes.

Components

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors

Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors

Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis. *See catalog for pricing.*

Finder Scopes

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White enameled metal tube.

6x30mm — Same unit used on $1000+ "big name" telescopes. With 2-ring bracket, fits scopes 6"-12". #13023 **$44.50** (3.41)

6x30mm Right Angle — 90° prism for right-angle viewing. Includes bracket. #13021 **$59.95** (3.41)

NEW! 8x50mm — 2.7x light grasp of 30mm models. Bright 6.25mm exit pupil. #7090 **$64.50** (3.41)

NEW! 8x50mm Illuminated—Wireless illuminator with adjustable brightness. #7092 **$94.50** (3.41)

NEW! 9x60mm — 44% more light grasp than 50mm models. #7091 **$99.50** (3.41)

NEW! 9x60mm Illuminated—Wireless illuminator with adjustable brightness. #7093 **$134.50** (3.41)

Mounting Brackets - 2-ring design with non-marring adjusting screws. Fits any scope 6" and over including Celestron & Meade SCs

8x50mm bracket #5143 **$27.95** (2.98)
9x60mm bracket #5041 **$32.95** (2.98)

Rack-and-Pinion Focusers

Finest in their class. Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.

1.25" #13007 **$49.95** (2.98)

2.0" includes 1.25" adapter. #13003 **$89.95** (3.95)

NEW! Low-Profile Focusers

Perfect for fast optical systems. Ideal replacements for "Odyssey" scopes.

1.25"-#13014 **$39.50** (2.45)
2.0" - #13016 **$59.50** (2.98)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Astronomer's Flashlight #5701 **$9.95** (1.79)
Nitewriter Pen #5709 **$8.95** (1.79)
Hands-Free Flex Light #5707 **$17.95** (2.43)
Starlite LED Flashlight #5714 **$24.95** (2.43)
Celestron LED Flashlight #5720 **$19.95** (2.43)

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 **$39.95** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 **$89.95** (8.02)

Accessories See Our Catalog for Even More!

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.

1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792

$44.95 ea. (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals let you view at a right angle from the direction your telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.

1.25" Star Diagonal
#8763 **$43.95** (2.98)

.965" Star Diagonal
#8761 **$26.95** (2.98)

Hybrid 1.25"/.965" Star Diagonal
#14008 **$31.50** (2.98)

2" Prism/Mirror Diagonals

2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.

For refractors #8770
For Schmidt-Cass. #8771
$199 ea. (4.71)

2" Mirror Diagonal–Affordable, high-quality star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$99.95 ea.** (3.45)

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965" #5268 **$26.95** (2.98)
1.25" #5264 **$29.50** (2.98)
Hybrid 1.25"/.965" #8782 **$29.50** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.

#5262 **$38.50** (2.98)

Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender #5125 **$27.95** (2.98)
Variable Tele-Extender #5127 **$37.95** (2.98)

T-Adapters

Threads to rear cell of telescope, requires t-ring for your camera model.

for SC #5116, *for C-90* #7115 **$26.50** (2.98)

T-Rings

Available for many different camera types, call toll-free or see our catalog for your particular model.

Multi-Function Focal Tester

Allows easy, accurate, ultra-sharp focusing, essential for astrophotography.

#7109 **$159** (4.19)

Tripods

Bogen/Velbon/more!
Huge selection of tripods available, for telescopes, spotting scopes and giant binoculars. Choose from assembled models or mix-and-match pan heads and tripod legs, sold separately. See our catalog for details.

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7012 **$44.50** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.

#5014 **$15.95 each** (2.43)

StereoScope Viewer

For comfortable two-eyes-open observing. You won't believe the views! Threads securely to the rear cell of your telescope. Requires two identical eyepieces.

#9720 **$479** (5.71)

f/6.3 Reducer/Corrector

Get f/6.3 performance from your f/10 Schmidt-Cassegrain.

#5120 **$169** (3.67)

NEW! Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

Orion's new Sky Wizards are electronic marvels that will put the magic back in your astronomical observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few relaxed hours — without using star charts!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Complete system requires Sky Wizard Model 1 or 2 and a telescope installation package, sold separately.

Encoders and cables available separately for custom installations. Call for details.

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets.
#7801 **$219** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice.
#7802 **$319** (4.44)

Installation Packages
Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.

Celestron Super Polaris	#27100	**$207** (5.29)
Celestron Ultima 8" & 11"	#27101	**$177** (5.29)
Celestron Classic 8" & Powerstar 8"	#27102	**$177** (5.29)
Meade 8" & 10"	#27103	**$202** (5.29)
Dobsonian (fits Coulter and most others) Call for stock # for your model		**$177** (5.29)

Installation packages available for other telescopes.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.

#5144 **$49.95** (3.45)

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.

#5139 **$119** (4.19)

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.

#17001 **$69.95** (3.95)

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.

#2354 **$109** (8.97)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

Many other sizes available—see our free catalog for details.

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 **$14.95 ea.** (2.43)

Color Eyepiece Filters

Highest quality precision-ground optical glass. Fully anti-reflective coated. Solar system observations are dramatically improved. Thread into the barrel of any standard eyepiece, or directly into a universal camera adapter.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow.
#5510 **$39.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$44.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets.
#5517 **$79.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set.
#5575 **$119 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow.
#5513 **$84.95 set** (3.96)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters—Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces.
#5660 **$54.95** (3.45)

SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes.
#5658 **$79.95** (3.45)

52mm Broadband Filter–For 52mm camera lenses, (Adapter rings available for other diameters.)
#5668 **$74.95** (3.45)

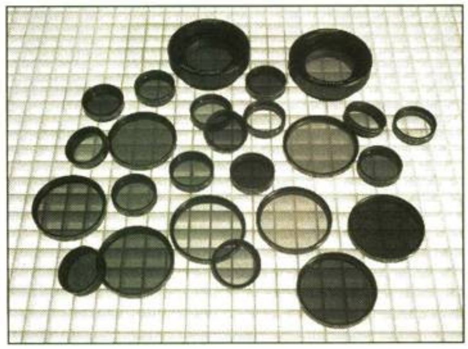
2.0" Broadband Filter–fits 2" eyepieces.
#5659 **$89.95** (3.45)

.965" Broadband Filter–fits .965" eyepieces.
#5661 **$39.95** (2.98)

SkyGlow UltraBlock Filters–Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces.
#5654 **$79.95** (3.45)

SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes.
#5656 **$109** (3.67)



Eyepieces & Barlows

✧ Sirius™ Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for 'famous name' Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!

Sirius Plössls are top-quality, 50° apparent field eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of reflector, refractor and catadioptric telescopes. The Plössl design is renowned for its fantastic performance and has in recent years become the standard by which all other eyepieces are compared.

Each eyepiece is of the classic 4-element Plössl design. Every air-to-glass surface is fully Magnesium Fluoride anti-reflection coated. All lens edges are blackened in the same way as expensive military optics, to further eliminate any scattering of stray light and to maximize contrast.

The optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

We guarantee that you'll be impressed with the performance of the Sirius Plössls, even when compared to the more expensive name-brand Plössls.

25mm #8530, *17mm* #8531,
10mm #8532, *7.5mm* #8533

Sale! $47.50 each (3.45)
Set of 4 in foam-lined case
#8534 **Sale! $177** (4.71)

Explorer .965" & 1.25" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anondized, internally blackened, threaded for filters (except 40mm .965").

.965 Orthoscopic
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583
$49.50 each (2.98)

.965 Kellner
18mm #8584, **25mm** #8585
$37.50 each (2.98)

.965 Achromatic Huygenian
40mm #8586
$37.50 (2.98)

1.25" Orthoscopic
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$54.50 each (2.98)

1.25" Kellner
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$43.50 each (2.98)

Superb Ultrascopic™ Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7-element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Guaranteed to beat other brands selling for much more! Unsurpassed high-performance design!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$74.95 ea.** (3.45)

Wide Field 5-element
25mm #8564 **$89.95** (3.45)
30mm #8562 **$94.95** (3.45)
35mm #8560 **$99.95** (3.45)

***High Power 7-element** —Long Eye Relief*
5mm #8574, **3.8mm** #8576
$84.95 ea. (3.45)

MegaVista 1.25" & 2" Eyepieces

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Deep-Sky Summer: THE MILKY WAY

Step right up and meet some of the most glorious sights in the summer sky.

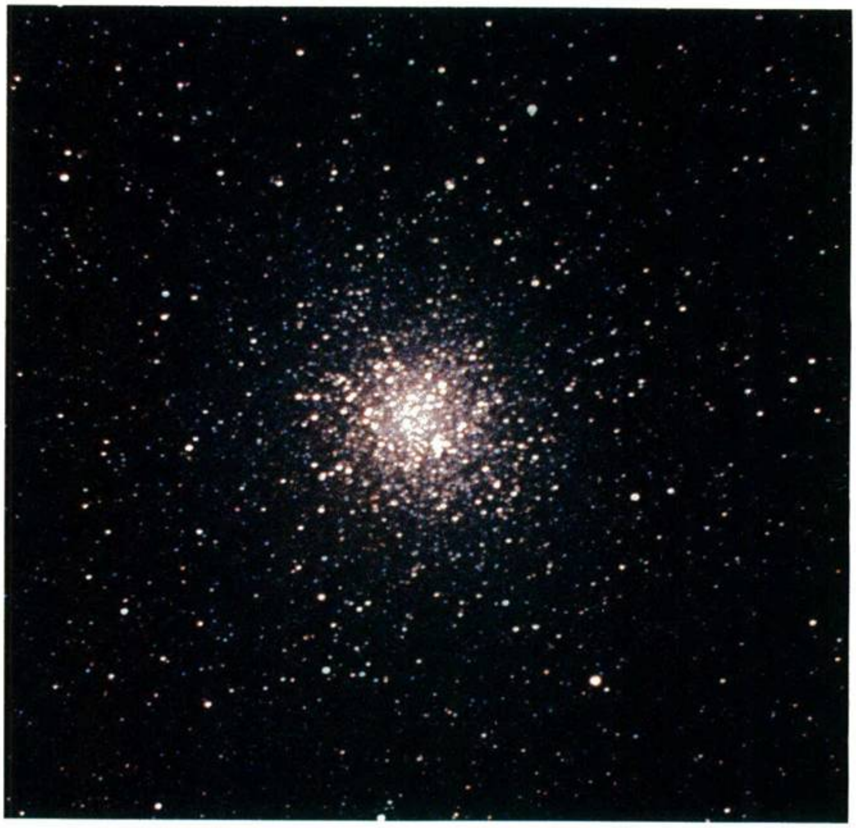
by David J. Eicher

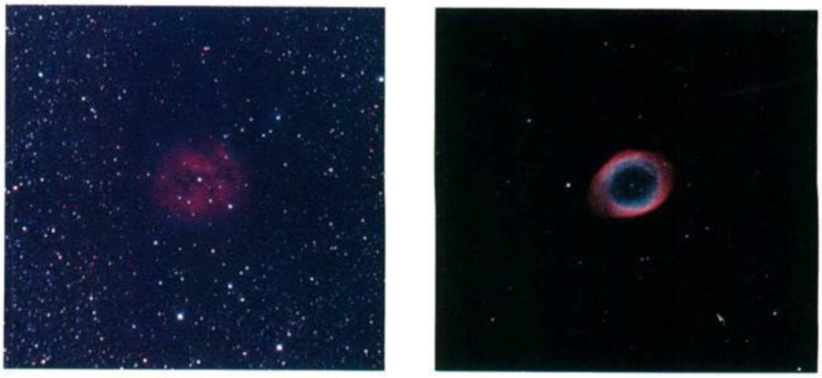
Summertime is magic for amateur astronomers. A few steps outside, a look skyward, and you find yourself surrounded by comfortable temperatures and a dark sky radiant with stars. As the Sun sets and darkness falls, as the great dome of stars wheels westward, the riches of our Milky Way Galaxy lie before you.

Arching overhead like a great path of misty light, the summer Milky Way is the most remarkable naked-eye feature of the sky. Bright, easy-to-find star clusters and gaseous nebulae lie scattered along the plane of the Galaxy from Centaurus in the south to Cygnus in the north, with the richest hunting ground lying at a point between Sagittarius and Scorpius. With a pair of binoculars or a small telescope and a star atlas at the ready, you can dive into the great adventure of viewing spectacular treasures in our home Galaxy.

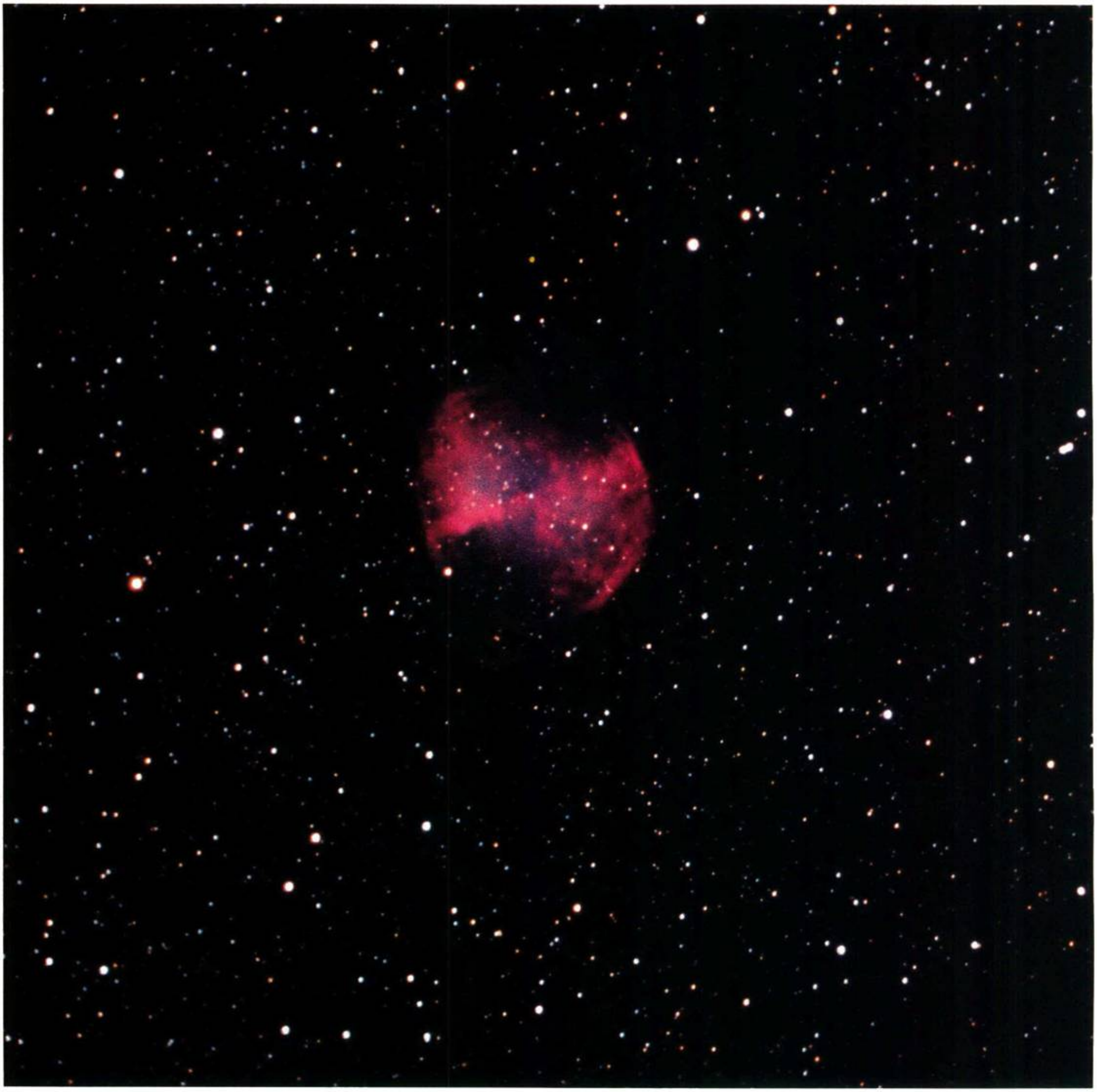
The Wild Duck Cluster (M11). As open star clusters go, Scutum's Wild Duck Cluster is a humdinger. At magnitude 5.8, this group of blue-white stars is visible to the naked eye on a dark night. It appears as the brightest patch inside a large glow in the Milky Way called the Scutum Star Cloud, a dense region of stars accentuated by the surrounding dark nebulae. The Wild Duck Cluster becomes a more beautiful sight in binoculars. They show it as a triangular glow with a few bright stars sparkling through. The entire object measures about 1/3 the diameter of the Moon.

Globular star cluster M22. Located in the northeast corner of the Teapot asterism in Sagittarius, this is a globelike cluster of several hundred thousand stars lying far below the plane of our Galaxy. An exceptionally dark night will show M22 to the eye alone, but you'll need binoculars





CLUSTERS AND NEBULAE ABOUND in the summer sky, including easily found examples like the Omega Nebula (opposite; photo by Michael Stecker), globular cluster M22 (top; photo by Christopher Galfo), the Cocoon Nebula (above left; photo by Jack Newton), and the Ring Nebula (above right; photo by Jack Marling).



THE DUMBBELL NEBULA in Vulpecula (above) remains one of the most spectacular planetary nebulae in the sky. Photo by Tony Hallas and Daphne Mount. Nearby in Cygnus lies the complex of nebulosity containing the North America Nebula and the Pelican Nebula (left). Photo by Michael Stecker.

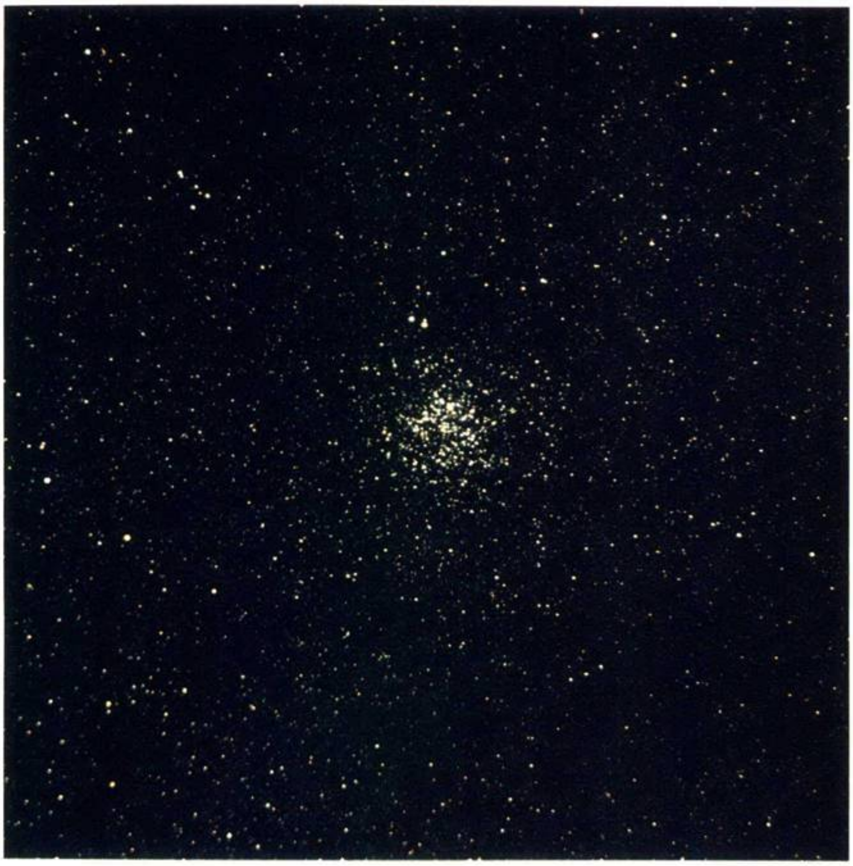
or a small telescope to see this object well. When the scope is aimed correctly, you'll see a small, circular glow peppered with a few of the cluster's brightest stars. Before reaching your eye, this light has been traveling for 10,000 years.

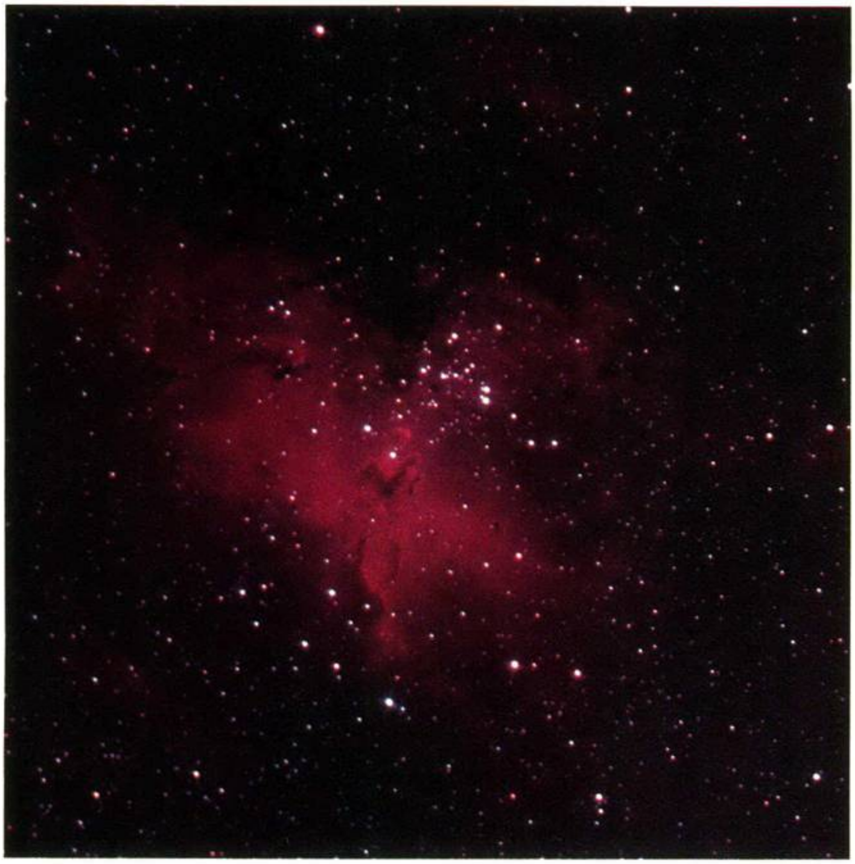
The Eagle (M16) and Omega (M17) nebulae. A mere 2° separate two bright clouds of gas with associated star clusters, one lying in Sagittarius (M17) and the other in Serpens (M16). Each of these objects is a grand example of an emission nebula, easily visible in a small scope on a moonless night. Try M17 first, as it has a higher surface brightness and stands out more clearly against the background sky. It appears as an omega-shaped bar of light. The Eagle Nebula presents more of a challenge, but you should see its milky glow with a 3-inch or larger scope on dark, transparent nights.

The North America (NGC 7000) and Cocoon (IC 5146) nebulae. The North America Nebula has got to be the most overlooked naked-eye deep-sky object of all time. Though it has a reputation for faintness, this large glow southeast of the bright star Deneb is plainly visible to the eye on any dark night when Cygnus lies overhead. Try using averted vision (glancing slightly to the side) when you observe this subtle cloud of light. For a more challenging object, try the Cocoon Nebula, also in Cygnus. Small scopes show it as a faint, circular glow lying in a tunnel of dark nebulosity.

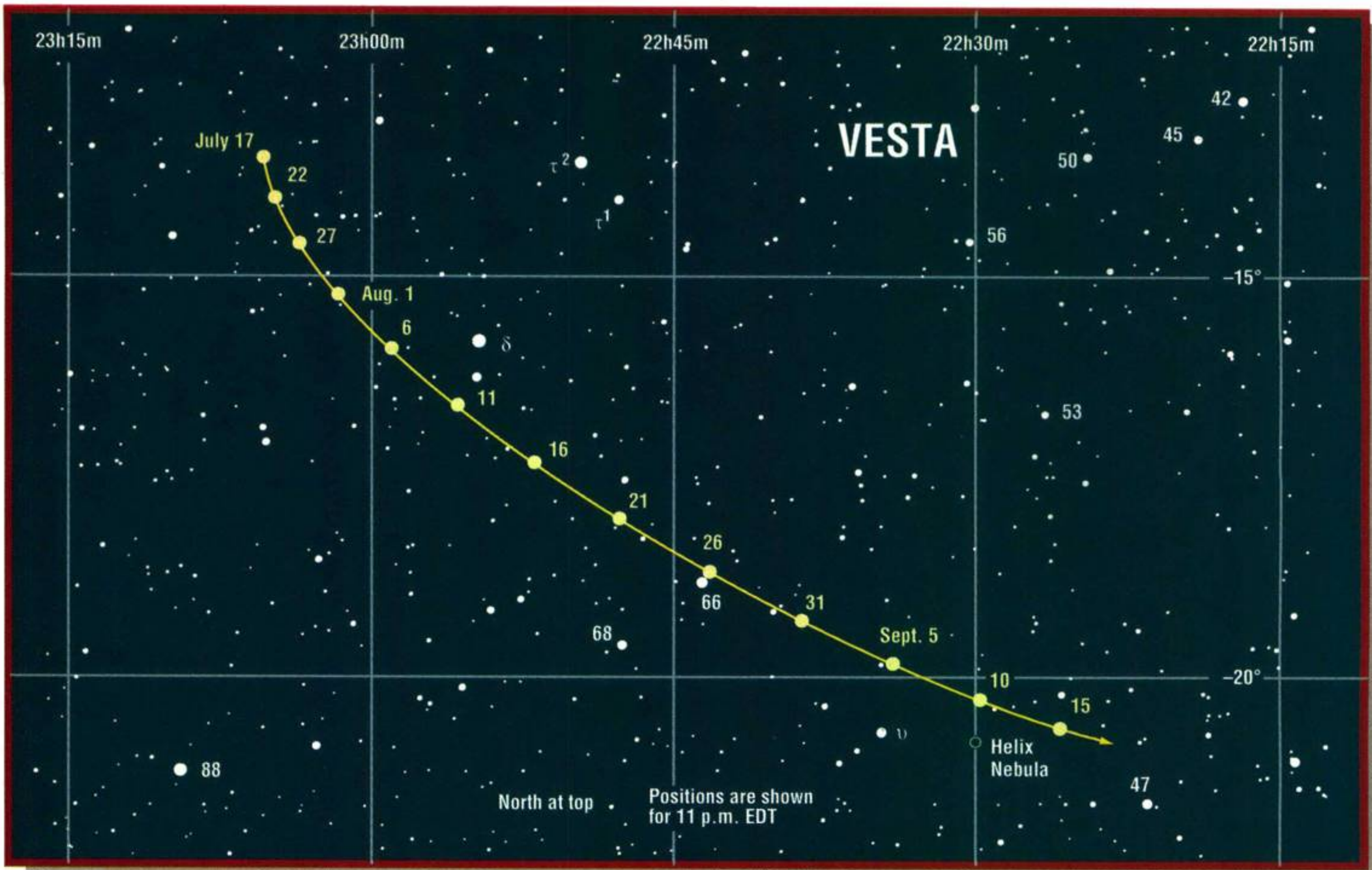
The Dumbbell (M27) and Ring (M57) nebulae. Two great planetary nebulae lie in the tiny constellations Vulpecula (the Dumbbell) and Lyra (the Ring). These remnants of dead stars appear as gray-green disks of eerie light, much like Uranus and Neptune, hence the name planetary nebulae. The Dumbbell earned its name because it does indeed appear to be shaped like a weightlifter's dumbbell. It is quite bright, visible in binoculars on dark nights. Use low power to find these objects and then switch to high powers to get a good view. The Ring Nebula looks like a smoke ring in small telescopes, which are necessary to magnify the small nebula sufficiently.

These deep-sky objects represent a mere taste of the sights awaiting you beneath the subtly glowing arch of the Milky Way. Given a little experience with your telescope or binoculars, you'll gain some momentum in your search for the distant denizens of the cosmos and become a first-rate deep-sky expert. ☐





BRIGHT SUMMER CLUSTERS are visible in small telescopes. The Wild Duck Cluster in Scutum (top) contains several hundred stars visible in an 8-inch scope. The star cluster M16 in Serpens (above) is surrounded by the bright gas cloud called the Eagle Nebula. Photos by Jack Newton.


23h15m
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22h45m
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VESTA
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Helix Nebula
47
88

North at top

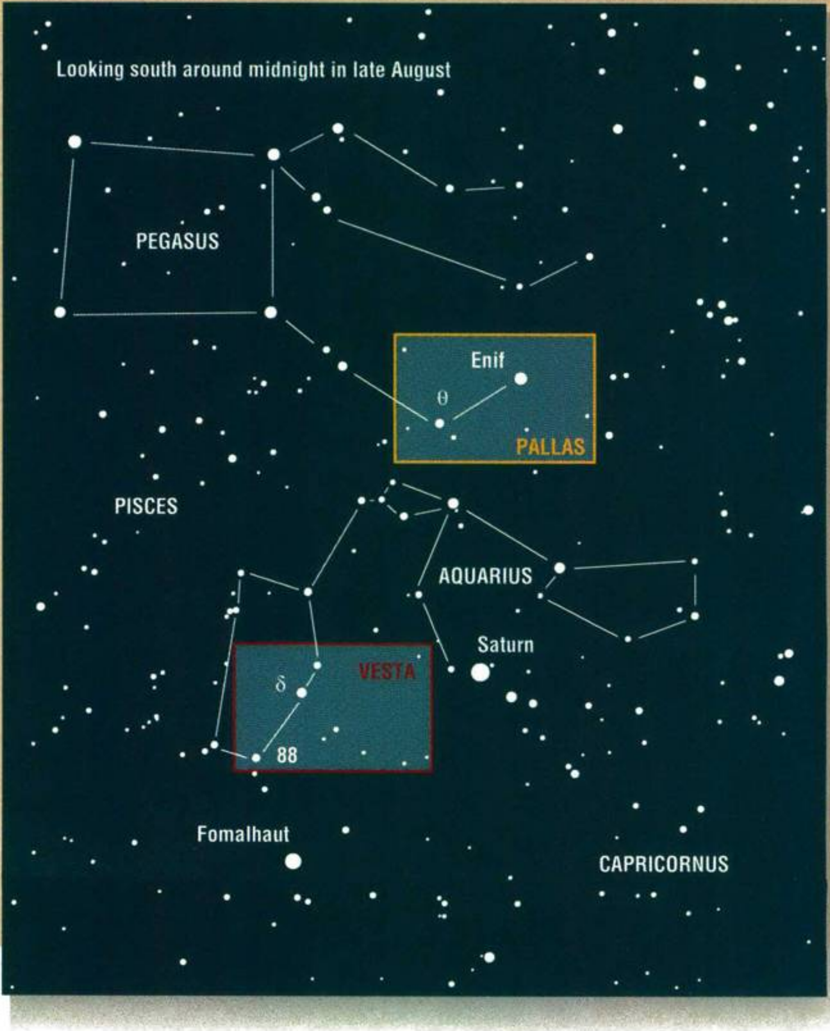
Positions are shown for 11 p.m. EDT

ADVENTURES IN OBSERVING

A Double Dose of Asteroids

Vesta and Pallas rank among the biggest and brightest asteroids. This month you can view them as they reach their peak of visibility in the late summer sky.

by Richard Talcott



Looking south around midnight in late August

PEGASUS
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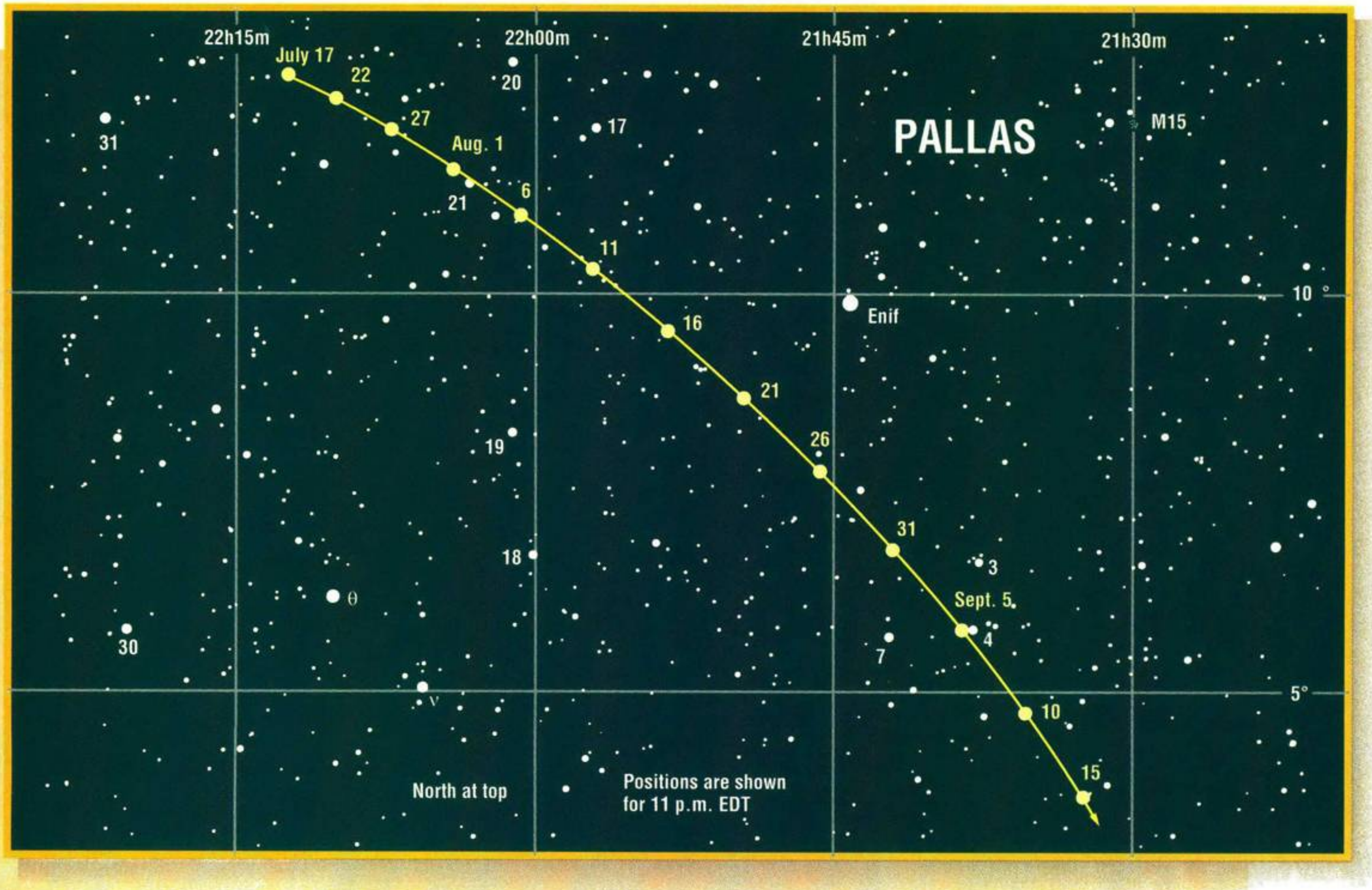
Fomalhaut
CAPRICORNUS



PALLAS

North at top

Positions are shown for 11 p.m. EDT

Although the Perseid meteor shower and the opposition of Saturn overshadow all other celestial happenings this August, don't let two other noteworthy events get lost in the shuffle. During the last week of August, the asteroids 4 Vesta and 2 Pallas lie opposite the Sun in the sky, appearing at their brightest and staying in the sky all night long. If you've never seen an asteroid (minor planet) before or just want to get reacquainted with some old solar system friends, this is your chance.

These two objects rank among the brightest asteroids — a collection of thousands of rocky bodies that circle the Sun, most between the orbits of Mars and Jupiter. Vesta is the only asteroid that ever shines brightly enough to see with your naked eye and this year it glows brighter than usual. And although Pallas appears somewhat fainter, a pair of binoculars will easily show it to you.

As you might expect with both objects reaching opposition around the same time, Vesta and Pallas lie near each other in the sky. Vesta tracks through southern Aquarius during August and September while Pallas lies one constellation farther north, in southwestern Pegasus.

Use the wide-field finder chart at left to determine the location of each asteroid. The map shows the sky as it appears if you look due south around midnight during the last week of August. The dominant star pattern in this area is the Great Square of Pegasus at upper left, though the brightest point of light you'll see is golden-colored Saturn.

To spot Vesta with your naked eye, you'll need to find an observing location far removed from city lights. Even at its best, Vesta appears stellar and is only a bit brighter than the faintest stars you can see without optical aid. The easiest way to locate Vesta is with binoculars and the help of the closeup finder chart at top left. This chart shows stars down to magnitude 9.5, far fainter than 6th-magnitude Vesta, so you should have little problem spotting the solar system interloper. Then put your binoculars aside and see if you can detect the minor planet with only your eyes.

A good time to try is on August 12 and 13, when you may already be out looking for Perseid meteors. On these nights, Vesta skims 1° south of the 3rd-magnitude star Delta (δ) Aquarii. Vesta comes even closer to a 5th-magnitude star just one night before its August 27/28 opposition, passing a mere 0.1° north of 66 Aquarii.

Some three magnitudes fainter than Vesta, Pallas offers more of an observing challenge. Still, it is an easy target in binoculars or a small telescope, for it shines at magnitude 9.1 when it reaches opposition on the night of August 24/25.

The best time to search for Pallas is around opposition, when it lies near the conspicuous star Enif, which marks the nose of Pegasus the Flying Horse. On August 27 and 28, Pallas passes 2° south of this 2nd-magnitude star. (The waxing gibbous Moon then lies a comfortable 40° away.) And on September 5, Pallas passes less than 1 arcminute from the 6th-magnitude star 4 Pegasi. You can use the finder chart above to locate Pallas at other times in late July, August, and September.

Seeing Vesta and Pallas may spark a lifelong interest in asteroid observing. If so, you won't lack for observing targets for a long time — astronomers have now catalogued over 5,000 of these objects, hundreds of which can be seen in a small telescope. But even if Vesta and Pallas mark your only foray into the land of the asteroids, you will have found a great way to cap off a memorable August of observing. □

Gearing up for Those PERSEIDS

Get ready for a spectacular display of meteors when the Perseids peak on August 11/12.

by Philip M. Bagnall

Chris Cook

CREATOR OF THE PERSEIDS, Comet Swift-Tuttle was first observed in 1348. In 1866 astronomers predicted its return sometime in the 1980s, but the tardy comet showed up in 1992. The cloud of debris that accompanies the comet suggests enhanced activity for the Perseid shower this year.

The annual Perseid meteor shower is the greatest of the year. Characterized by lots of bright meteors, often with persistent trains, its clockwork regularity coupled with hot August nights is sufficient to coax even the most armchair-bound astronomer out under the stars.

Some observers take great pains to record, as accurately as possible, the behavior of the shower. But many more observers just lie back in a lawn chair and watch one of Nature's most beautiful sights: a speck of dust burning up high in the atmosphere.

If you've never witnessed the glory of the Perseid meteor shower, this year offers an ideal start. It seems at least possible — perhaps likely — that this year's display will be the most spectacular ever.

Prospects for 1993

This year the shower should be active between about July 20 and August 25, peaking on August 11/12. The *British Astronomical Association Handbook* gives the peak at 15h UT — favoring observers in Asia — but Paul Roggemans of the International Meteor Organization predicts enhanced activity between 22h UT and 3h UT on August 11/12, which is good news for European observers. Paul has based his prediction on the belief that the stream now has three main components — a well established core, a fringe of meteoroids, and a rich filament recently released by its parent comet, Swift-Tuttle. It is this last component that encounters Earth several hours before the main core.

Perseid meteors appear to radiate from a point near the star Eta Persei at R.A. 3h06m, Dec. +58°. But the position of the radiant drifts by eastward 1.35° per day in R.A. and northward 0.12° per day in Dec. Furthermore, there may well be more than one active radiant.

The radiant is actually an optical illusion. Perseid meteoroids enter Earth's atmosphere more or less parallel to one another but, seen from a distance, they appear to converge to a point just as the parallel tracks of a railroad appear to converge to a point on the horizon.

Perseid meteors tend to be fairly bright with long, persistent trains. They enter the atmosphere at about 135,000 miles per hour and "burn up" at between 60 and 70 miles altitude. This combination of brilliance and swiftness often gives observers the impression that the meteors are sweeping past close to the ground.

Last year observations were hampered by a Full Moon that washed out most of the faint meteors. This year the Moon will be 24 days old — just a few days before New, and will not spoil observations.

Shower with a Friend!

Observing the Perseids could not be easier. Simply lie back in a lawn chair and concentrate on an area of sky approximately 45° from the radiant and about the same distance above the horizon. Start observing after midnight. This allows Earth to turn into the stream and the radiant a chance to climb to a reasonable height. Within a few minutes you should begin to witness the Perseids.

If you want to do some serious observing then you could record the time each meteor appears (in UT), its magnitude (compare it to the stars it passes close to), and its color. Additional information, such as the appearance of the train and how long it lasted is always useful. Observe for an hour and then

Matthew Groshek

Charles Manion

Craig Stott

Frances Gauger

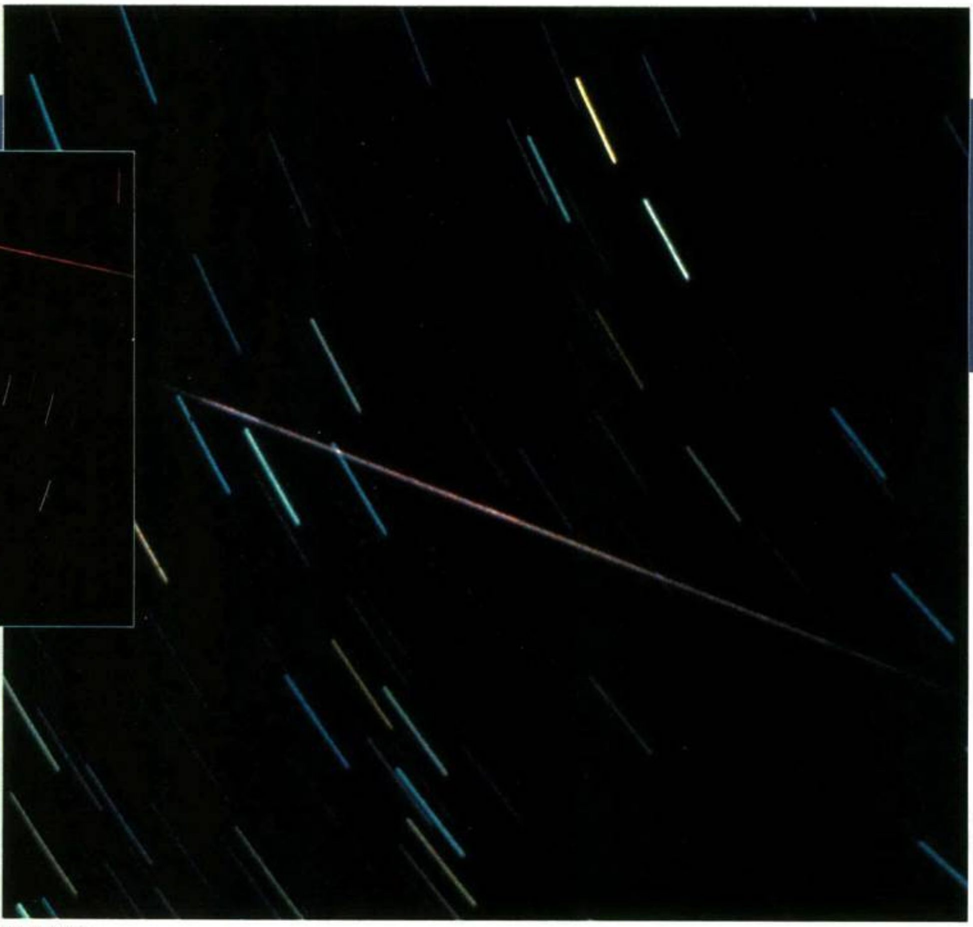
L. Allen Beers

A GALLERY OF PERSEID SHOTS shows the many appearances of Perseid meteors captured by ASTRONOMY readers. Bright Perseids flare as they disintegrate (top left). Others are quite bright but brief in duration (above). Long exposures increase the chances of recording a meteor (left). Occasionally readers have captured an auroral show along with a Perseid (bottom left).

take a ten minute break: having a warm drink and something to eat will help you keep awake and alert. If you are observing from the far north make sure you wrap up warmly. Always work under red illumination to maintain dark adaption, and don't keep the observations to yourself— there are many meteor organizations that would appreciate them. Among these are the American Meteor Society (Dept. of Physics and Astronomy, SUNY, Geneseo, NY 14454) and the International Meteor Organization (Physics Dept., University of Western Ontario, London, ON N6A 3K7).

The Perseids are ideal for photography. Forget about drives and piggybacks — fix your camera onto a firm tripod, keep it as close to the ground as possible to avoid vibration from wind, and point it to the area of sky you are watching. Use a fast film (ISO 200+) and lens (f/2 or faster), preferably one with a fairly wide view (say a 35mm or 28mm lens on a standard 35mm SLR). Lock the shutter open and close it after ten minutes, or earlier if you think you have captured a meteor on the film. If you live in or near a light-polluted city you may well be restricted to exposure times of

Alex York and Martin Anderson



Rick Schmidt

THE SIGNATURE of a Perseid streaks across Cassiopeia in many long-exposure photos made by meteor hunters (above). Wide-field photography records the greatest number of meteors most quickly (right). Equipped with camera and tripod, astrophotographers frequently target bright constellations like Ursa Major hoping to capture a meteor in the frame (bottom right).

Mike Walters

five minutes or less before your film begins to fog. If the Perseids do put on a good display this year you may be lucky enough to capture at least some of them on film.

The Comet Connection

Why will this year's shower likely be so good? To understand we must find out something about comets. Comets are basically dirty snowballs of frozen gases peppered with millions of dust particles. In the cold wastes of the outer solar system, comets exist in a state of suspended animation: frozen, inert, undetectable. But as they approach the Sun they begin to heat and the ices start to sublimate — turning directly to gas without going through a liquid phase. Usually at this point we can begin to detect and observe the comet. The frozen snowball develops a nebulous coma, sometimes leaving behind a tail stretching millions of miles, and the comet takes on the more familiar appearance that has often adorned the pages of ASTRONOMY.

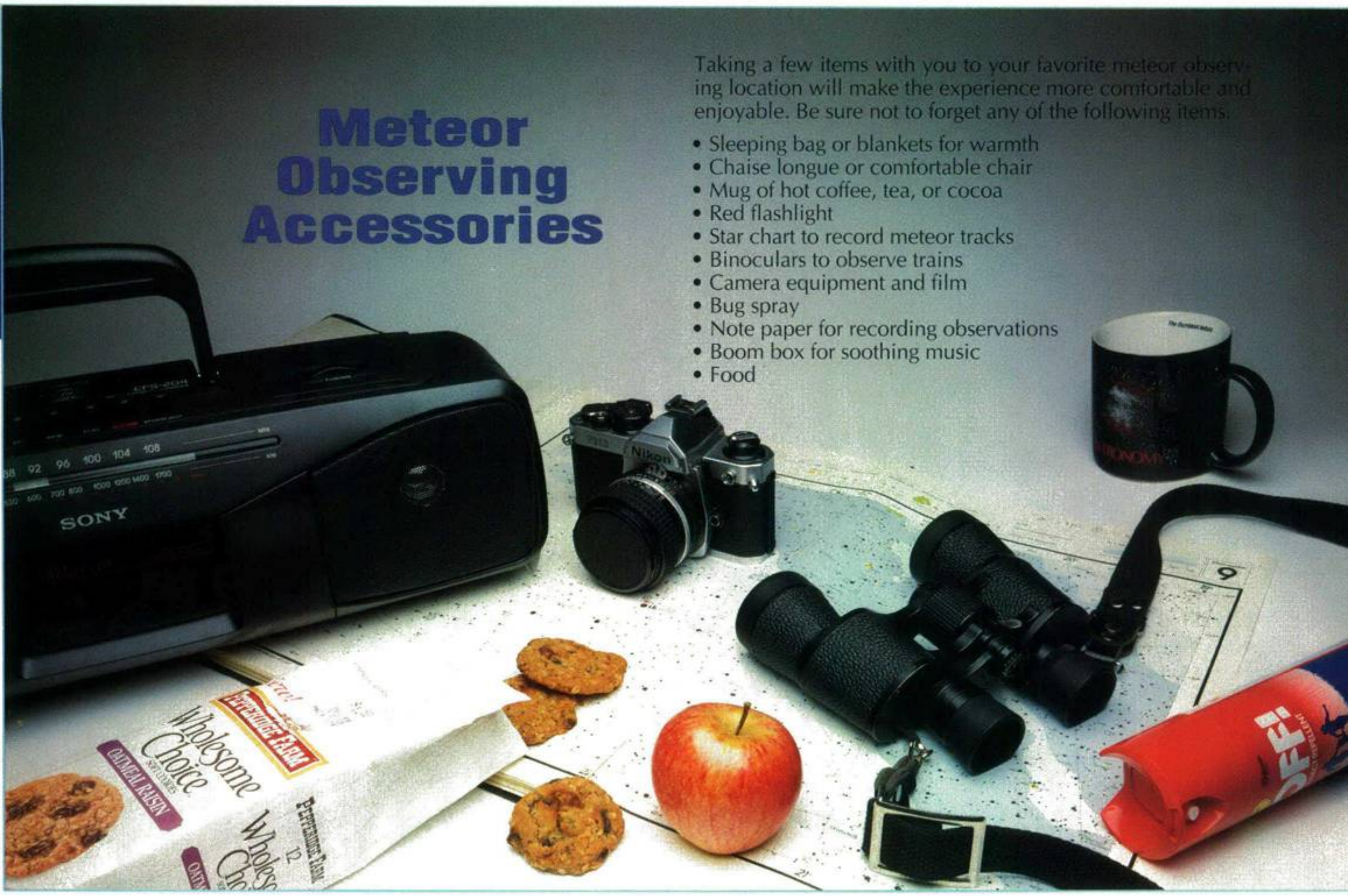
The particles left behind by the comet become a stream of meteoroids. If Earth encounters the resulting meteoroid stream, the meteoroids slam into our atmosphere at velocities of up to 72 kilometers per second (162,000 miles per hour). At these high velocities, friction of even the thin air of the upper atmosphere — 100 kilometers above our heads — is so great it causes the outer layers of the meteoroid to melt.

The high temperatures of the atoms flowing off of the surface ionize atoms and molecules in the surrounding air, briefly energizing them. As they lose this energy the atoms and molecules give off light, which we observe as a brief streak across the night sky: a meteor. So every time you see a meteor "burn up" in the sky you are actually watching a fragment of a comet come to its glorious end.

Comet Swift-Tuttle

In 1866 the Italian astronomer Giovanni Schiaparelli realized that the orbit of the Perseid meteoroid stream was very similar to that of a bright comet discovered in 1862 by the veteran comet hunter Lewis Swift and the Civil War soldier — and embezzler — Horace P. Tuttle. Schiaparelli was able to calculate the comet's orbital period as 120 years, which meant that it should have returned to perihelion in about 1980-82. However, despite intensive searches, the comet was not found. Astronomers did observe enhanced meteor activity from the Perseids in 1980 which led to speculation that the comet had come and gone without anyone noticing it. All sorts of hypotheses were proposed to account for this. Some believed the comet had split into two or more pieces and was no longer bright enough to be easily observed. Others argued that the orbital calculations were off by a couple of years. Some even suggested the comet had developed an insulating coat preventing it from brightening and displaying a coma.

The one person who had it all worked out was Brian Marsden, a British-born astronomer working at



ASTRONOMY: Chris Becker

Meteor Observing Accessories

Taking a few items with you to your favorite meteor observing location will make the experience more comfortable and enjoyable. Be sure not to forget any of the following items:

- Sleeping bag or blankets for warmth
- Chaise longue or comfortable chair
- Mug of hot coffee, tea, or cocoa
- Red flashlight
- Star chart to record meteor tracks
- Binoculars to observe trains
- Camera equipment and film
- Bug spray
- Note paper for recording observations
- Boom box for soothing music
- Food

the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. As long ago as 1973 Marsden had realized that a comet observed by a Jesuit missionary in July 1737 could well be P/Swift-Tuttle — the P/ indicates it is a comet with an orbital period of less than 200 years.

Marsden calculated previous perihelion returns for March 1610 and December 1479 but showed that the comet would be badly placed and could not have been observed from Earth. However, a further apparition in September 1348 seemed more promising and, indeed, a search of Japanese records revealed the appearance of a prominent comet in the sky that year. Using an orbital period of about 130 years, Marsden predicted Swift-Tuttle's return to perihelion for November 1992. His estimates were off by barely three weeks. Last September Japanese comet hunter Tsuruhiko Kiuchi recovered periodic comet Swift-Tuttle, ending years of speculation over why the comet failed to appear in the early 1980s.

P/Swift-Tuttle reached perihelion — its closest point to the Sun — in December last year and is now heading back out into the depths of space. But it has left behind a rich and beautiful legacy. Scattered around its orbit is a new meteoroid-laden stream. During the next few weeks Earth will pass through this stream, running into meteoroids. The result should be a spectacular meteor display of Perseids in mid-August.

Perseids Past and Present

The Perseids are one of the oldest known meteor showers with reports going back to China in A.D. 36. At that time the shower was active in July and on July 17 of that year the Court Astronomers of the Celestial Empire recorded that "in the morning small meteors numbering more than one hundred moved in all directions."

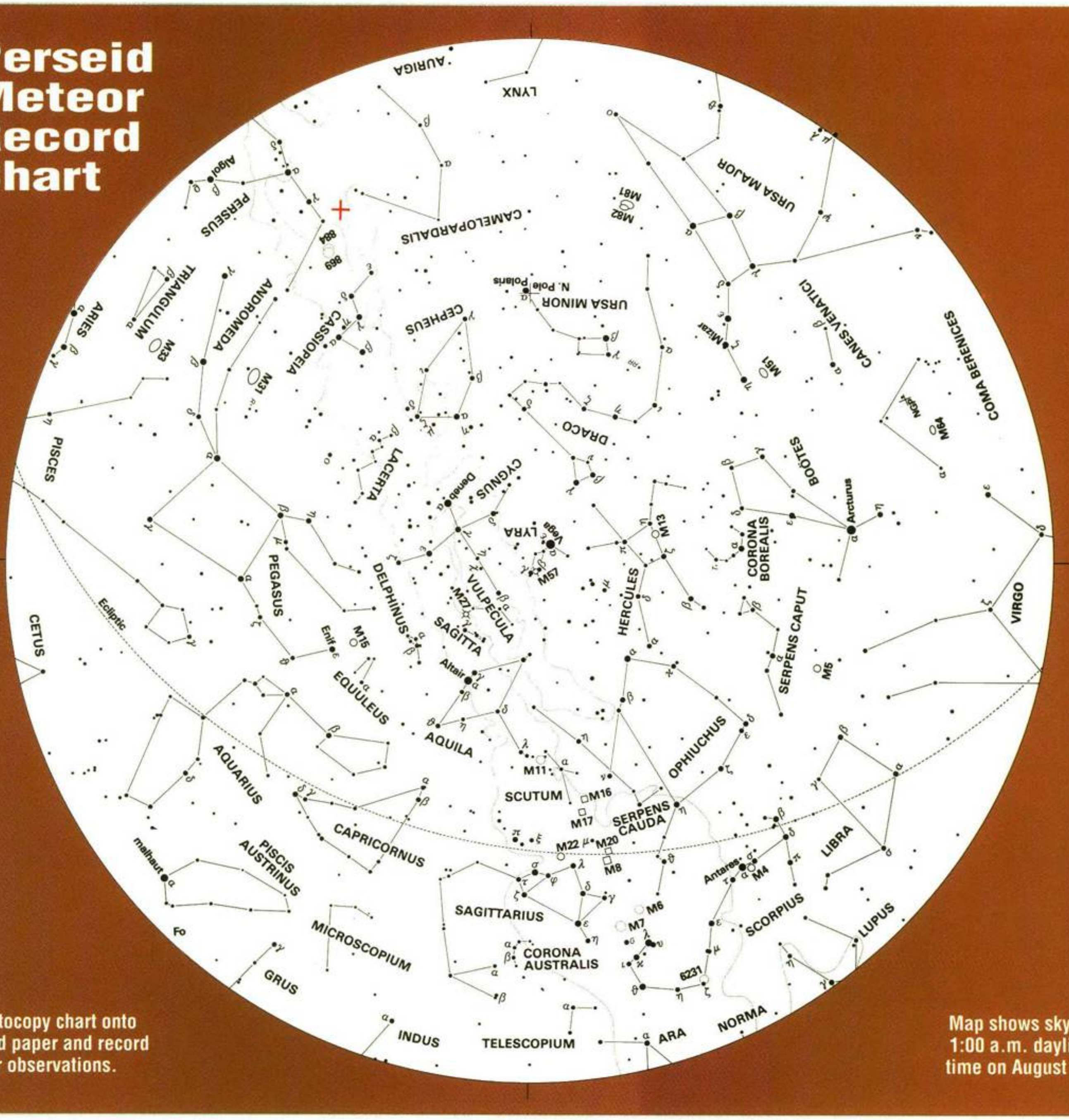
On August 10, A.D. 258, the Spaniard Saint Lawrence was put to death, becoming one of Christianity's many martyrs. His death coincided with the Perseids and even today some people still refer to the shower as the "Tears of St. Lawrence." Even so, Europeans did not systematically record the Perseids until A.D. 811.

The British amateur astronomer William F. Denning undertook the first modern study of the Perseids between 1869 and 1898. He recorded 50 meteors per hour on August 9/10. By 1911, however, the rate had dropped to a barely detectable four meteors per hour. This activity remained constant until 1920, when observers reported seeing 250 meteors per hour. The activity decreased to about 65 meteors per hour until the mid-1970s, when the rate began to increase gradually to a peak of 200 per hour in 1980. Since then the shower has been averaging about 70 meteors per hour until two years ago. In 1991 Japanese astronomers witnessed a brief but intense burst of activity. This encouraged observers to make a special effort to monitor the shower last year despite the fact that a Full Moon hampered observations by washing out all but the brightest meteors.

Last year saw mixed results. In the United States and Canada observers reported a good, but not exceptional, display. They did, however, note a large number of colorful meteors. Usually Perseid meteors are white or bluish-white, but 1992 saw the appearance of yellow-pink and copper-colored meteors.

In Japan, on the island of Okinawa, approximately 200 Perseids were seen between 19h00m and

Perseid Meteor Record Chart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CASSIOPEIA
TRIANGULUM
ARIES
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ANDROMEDA
M31
Mizar
M51
CANES VENATICI
COMA BERENICES
M64
DRACO
PISCES
LACERTA
CYGNUS
Deneb
LYRA
Vega
M57
M13
BOÖTES
Arcturus
CORONA BOREALIS
HERCULES
PEGASUS
DELPHINUS
VULPECULA
M27
SAGITTA
CETUS
Ecliptic
Enif
M15
Altair
EQUULEUS
SERPENS CAPUT
M5
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OPHIUCHUS
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M4
LIBRA
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LUPUS
MICROSCOPIUM
CORONA AUSTRALIS
6231
GRUS
INDUS
TELESCOPIUM
ARA
NORMA

Photocopy chart onto bond paper and record your observations.

Map shows sky for 1:00 a.m. daylight time on August 12.

THE PERSEID RADIANT lies in Perseus between the Double Cluster and the relatively faint constellation Camelopardalis. The best viewing time is between midnight and early morning, when Earth's night side rotates into the oncoming cloud of debris.

20h00m UT on August 11 — 63 of them within a ten-minute interval. What makes these observations even more remarkable is the fact that Japanese observers were working under hazy skies with a limiting magnitude — the faintest star visible to the naked eye — of 3.5. When corrected for these conditions the Zenithal Hourly Rate (ZHR) was found to be a staggering 8,000 meteors per hour. (The ZHR is the theoretical rate an observer would see if meteors were coming from the zenith with a clear sky limiting magnitude of 6.5.)

Chinese observers saw 33 meteors in 20 minutes beginning at 19h50m UT on August 12, while American radio astronomers recorded a brief but strong burst at about 19h30m UT on the 12th.

What all these observations seem to indicate is that the meteoroid stream is clumpy and only about 20,000 miles across. If you happen to be in the right place at the right time then you can see a fine display.

Meteor showers can be as unpredictable as their parent comets, so the expected onslaught of meteors this August may not materialize. But the thing with the Perseids is that you are never disappointed: when they are good they are very good — but when they are bad, well, they are still pretty good. ☐

Philip M. Bagnall is president of the Society of Meteoritophiles. He has profiled a number of meteor showers for ASTRONOMY. *The author acknowledges Dr. F. Richard Stephenson of Durham University for information on ancient Chinese observations.*

NEW MEADE® ADVANCED PRODUCTS AT LUMICON

"What an astounding combination of high performance and low price!" Jack Marling, Ph.D., owner of LUMICON

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7'' f/9 Apochromat **Only $5495**

7'' IN STOCK!

Meade 6'' f/9 Model 152ED Refractor shown with #1697 Computer.

See the Meade ad in this magazine for full specifications and product descriptions. ED = Extremely low dispersion glass which yields color-free virtually perfect images. PPEC = Permanent Periodic Error Correction "Smart Drive."

Model 102 ED 4'' f/9 Apochromat & mount (add $105 P&S)	**$2195**
Model 127 ED 5'' f/9 Apochromat & mount (add $125 P&S)	**$2795**
Model 152 ED 6'' f/9 Apochromat & mount (add $185 P&S)	**$4495**
Model 178 ED 7'' f/9 Apochromat & mount (add $215 P&S)	**$5495**
Medium format adapters ..... Mamiya 645, **$98;** Pentax 6X7,	**$98**
Med. format EASY-GUIDER™: Mamiya 645, **$298;** Pentax 6X7,	**$298**

DRIVE SYSTEMS

#1664 Electronic Drive with PPEC & 2X, 32X slewing system	**$375**
#1697 Computer Drive, 747 object computer memory, automatic slewing to desired object	**$695**
8,000 Object CNGC Library .. **$99** Polar alignment finder	**$99**

OPTICAL TUBE ASSEMBLIES (OTA)

Model 102 ED/OTA 4'' f/9 CTA only (add $55 P&S)	**$1045**
Model 127 ED/APO-OTA 5'' f/9 OTA only (add $60 P&S)	**$1595**
Model 152 ED/APO-OTA 6'' f/9 OTA only (add $100 P&S)	**$2295**
Model 178 ED/APO-OTA 7'' f/9 OTA only (add $120 P&S)	**$3250**
Cradle ring assem. 4'' (4½'' OD tube) **$145;** 5'' (5½'' OD tube)	**$159**
Cradle ring assem. 6'' (7'' OD tube) **$189;** 7'' (8'' OD tube)	**$240**

EQUATORIAL MOUNTS

LXD 600 mount and standard field tripod (add $60 P&S)	**$1350**
LXD 700 mount and giant field tripod (add $100 P&S)	**$2250**

NOTE: Add the indicated packing and shipping (P&S) costs to each telescope for insured UPS shipment to your door.

MEADE SERIES 4000 PREMIUM EYEPIECES

6.4, 9.4, 12.4, 15, 20, 26mm Plossl	**$88**
32mm, 40mm Super Plossl	**$110**
56mm Super Plossl (2'') ***THE BEST****	**$230**
13.8mm Super Wide Angle	**$140**
18mm Super Wide Angle	**$150**
24.5mm Super Wide Angle	**$170**
32mm Super Wide Angle (2'')	**$240**
40mm Super Wide Angle (2'')	**$299**
4.7mm Ultra Wide Angle	**$155**
6.7mm Ultra Wide Angle	**$188**
8.8mm Ultra Wide Angle (1¼/2'')	**$230**
14mm Ultra Wide Angle (1¼/2'')	**$270**

Shipping charges of 1-2% are extra.

**Plossl test, "SKY & TELESCOPE," p490-492, May 1988*

MEADE LX100 & LX200 SCHMIDT-CASSEGRAINS

8'' LX200 **$2295**

NEW Meade 8'' LX200 Telescopes

See the Meade ad in this magazine for full specifications & details. **LX100 Drive,** 2X, 32X speed control with PPEC (Permanent Periodic Error Correction "Smart Drive") & dual-axis hand controller. **LX200 Drive,** Full electronic control with PPEC, 747 object computer memory and automatic computer controlled slewing to desired object. *NOTE:* A wedge is **not** needed for visual observing with the LX200 Drive.

8'' LX100 Schmidt-Cassegrain with wedge (add $105 P&S)	**$1995**
8'' LX200 Schmidt-Cassegrain with computer (add $105 P&S)	**$2295**
Wedge for photographing with 8'' LX200	**$110**
10'' LX100 Schmidt-Cassegrain w/super wedge (add $145 P&S)	**$2695**
10'' LX200 Schmidt-Cassegrain with computer (add $145 P&S)	**$2595**
Super Wedge for photography with 10'' LX200	**$395**
8,000 Object CNGC Library	**$99**

OTHER SCHMIDT-CASSEGRAINS

NEW! **SSC-8**, 8'' Schmidt-Cass on LXD-600 mount (add $105 P&S)	**$1795**
NEW! **SSC-10**, 10'' Schmidt-Cass on LXD-600 mount (add $145 P&S)	**$2095**
NEW! **SSC-12**, 12'' Schmidt Cass on LXD-700 mount (add $195 P&S)	**$3850**
NEW! **SSC-14**, 14'' Schmidt-Cass on LXD-700 mount	***Avail. Summer '94***
Meade 2045D 4'' f/10 with motor drive (add $40 P&S)	**$699**
Meade 2080B 8'' f/10 with tripod, wedge, MCOG (add $85 P&S)	**$1149**
NEW! Model 2120B 10'' f/10 w/wedge, tripod, MCOG (add $125)	**$1449**

PHOTOGRAPHY ACCESSORIES

LUMICON Cassegrain EASY-GUIDER f/6 or f/10	**$225**
LUMICON Giant EASY-GUIDER for 10'' f/5-f/10 operation	**$395**

MEADE STARFINDERS

8'' f/6 **$699***

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions and technical specifications for 6'' to 16'' Starfinders. These are complete telescope systems with motor drive, mount, finderscope and 25mm (=48X) eyepiece.

6'' f/8 Starfinder 6(add $50 P&S)	**$599**
8'' f/6 Starfinder 8 (add $60 P&S)	**$699**
10'' f/4.5 Starfinder 10 (add $75 P&S)	**$799**
16'' f/4.5 Starfinder 16 (ship. freight COD)	**$2195**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated shipping charge to the price. LUMICON showroom prices are $96 higher.

ACCESSORIES

LUMICON carries the full line of Meade accessories. See the Meade ad in this magazine for detailed prices and descriptions.

Meade #43 Single axis drive corrector	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector	**$450**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

LUMICON® SKY VECTOR™

Higher Performance — Lower Price

LUMICON ACCESSORIES

LUMICON, 2111 Research Dr., #5, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

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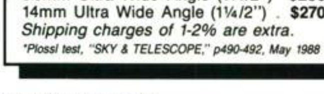
UP
DOWN
LUMICON

Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

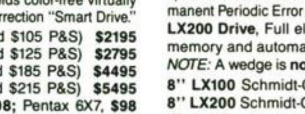
Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR



Coma 1 inch off-axis 17½'' f/4.5



Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

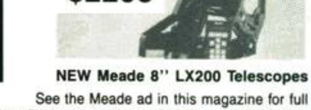
LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$169.50**
2'' EASY-GUIDER (Mamiya 645)	**$199.50**
2'' Adapter for Pentax 6x7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow) **$235.00**

LARGE UV/DUST SEAL



Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM $59.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$59.50**
LUMICON 2'' Helical Focuser 1½'' high	**$65.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' adapter w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$59.50**, right-angle	**$59.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$169**
1¼'' right-angle 80mm SUPER-FINDER	**$179.50**
1¼'' right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼'' eyepiece (12X)	**$39**
Large mounting rings for 80mm Finder	**$55**
1¼'' Star Diagonal **$39**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$52.44**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$26.00**
2'' adapter for C-80, C-100 refractor	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**16.00**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces*	**$26.00**
2'' long extension for 2'' eyepieces*	**$26.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing, threaded 48mm*	**$20.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

M-16, The Eagle Nebula, in Serpens. 45 minute photo by Tony Hallas and Daphne Mount using a 14" SCT and a LUMICON Giant Easy-Guider at f/7.5 with hypered TP 2415 film. "**If it wasn't for your accessories, these astrophotos wouldn't be possible,**" said Tony. M-16 is seen best with a LUMICON UHC Filter, and photographed best in color with a LUMICON Deep-Sky Filter.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90

Genesis 4" f/5 4 element fluorite	**$1595**
Pronto 70mm f/6.4 apochromat w/2" diagonal	**$798**
Pronto 70mm f/6.4 w/45° erecting prism	**$698**
Complete Equatorial Mount	**$795**
Motor Drive for above mount	**$239**
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	**$79**
1.8x or 2.5x Tele Vue Barlow Lens	**$89**
2" Giant Barlow - 2x	**$189**
32mm Plossl, widest true field in 1¼"	**$109**
55mm 2" Plossl, widest possible field	**$219**
15mm Wide-Field, 1¼" eyepiece, 65°	**$135**
19mm Wide-Field, 1¼" eyepiece, 65°	**$145**
24mm Wide-Field, "Rich-Field!" 65°	**$169**
32mm Wide-Field, 2" eyepiece, 65°	**$239**
40mm Wide-Field, "Rich-Field!" 65°	**$299**
4.8mm Nagler, 82° field, 1¼" eyepiece	**$149**
7mm Nagler, 1¼" eyepiece, 82° field	**$189**
9mm Nagler, 82° field, 1¼" or 2"	**$219**
11mm Nagler, 82° field, 1¼" or 2"	**$235**
13mm Nagler, 82° field, 1¼" or 2"	**$249**
12mm Nagler, Type II, 82°, 1¼"/2"	**$249**
16mm Nagler, Type II, 82°, 1¼"/2"	**$289**
20mm Nagler, Type II, 82°, 2" only	**$340**
1¼" Paracorr Visual Coma Corrector	**$159**
2" Paracorr Visual Coma Corrector	**$249**
NEW! 22mm Panoptic 1¼"/2", 68°	**$249**
NEW! 35mm Panoptic 2", 68° field	**$325**

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$49.00	$39.00
52, 55, 58, 62mm	$59.00	$49.00
67, 72, 77mm	$69.00	$59.00
82mm	$79.00	N/A

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for ***reflection*** *nebulae."*
Astronomy, Feb. 1991

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	**$59.50**
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	**$79.50**
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	**$119.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$119.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	**$299.50**
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$119.50** UHC, O-III, H-Beta,	**$199.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$199.50**
Set of both premium **DEEP-SKY** and **UHC Filters** (Save 11%) ... 1¼" **$159.50**; 48mm	**$279.50**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** ... **$99.50, 48mm**	**$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... **1¼" $99.50, 48mm**	**$199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	**$6.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	**$16.00**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	**$20.00**

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

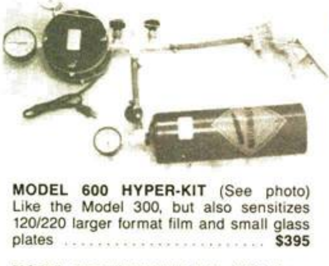
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

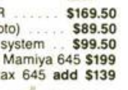
Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™



Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$169.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece system	**$99.50**

Guider for Hasselblad **$350**, Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad **$198,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ...... **add $99.95**
Adapter for Hasselblad **$229,** Mamiya 645**$129**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

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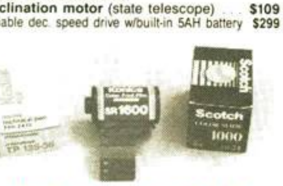

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Twenty years of great astrophotos

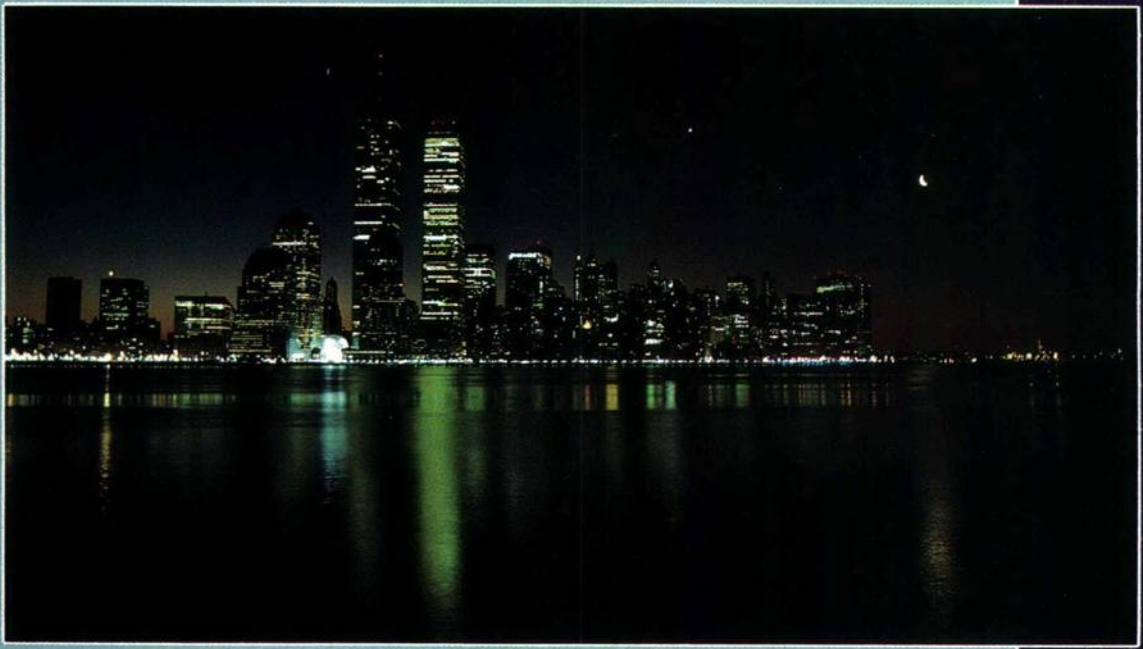
Here they are — a collection of smashing photos seen on our pages over the last 20 years.

"Gee, that's the best galaxy I've ever seen captured on a page." So a reader wrote when he saw a color photo of the Andromeda Galaxy in an issue of ASTRONOMY a couple of years ago. We're happy we've been able to publish great photos taken by our readers over the years. Indeed, readers have helped us reach one goal — to make ASTRONOMY "the world's most beautiful astronomy magazine."

ASTRONOMY was in its infancy when a Danish astronomer, Richard West, found a dim comet in 1975. The following spring the comet brightened to be one of the great comets of the century, and ASTRONOMY published page after page of spectacular portraits of it.

Through many events since Comet West (including a more famous comet's appearance ten years later), ASTRONOMY has brought to its readers the best astrophotos in the world.

[continued on page 91]

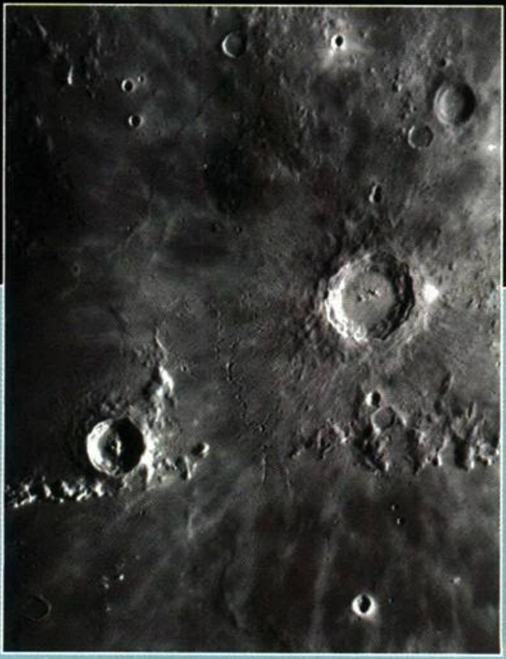


▲ **PLANETS OVER MANHATTAN**
February 21, 1990
Larry Landolfi

As New York concludes another night, Venus, Saturn, Mars, and the Moon light up the sky over the brilliant glow of Manhattan office buildings. This superb planetary conjunction was captured by Landolfi with a tripod-mounted camera.

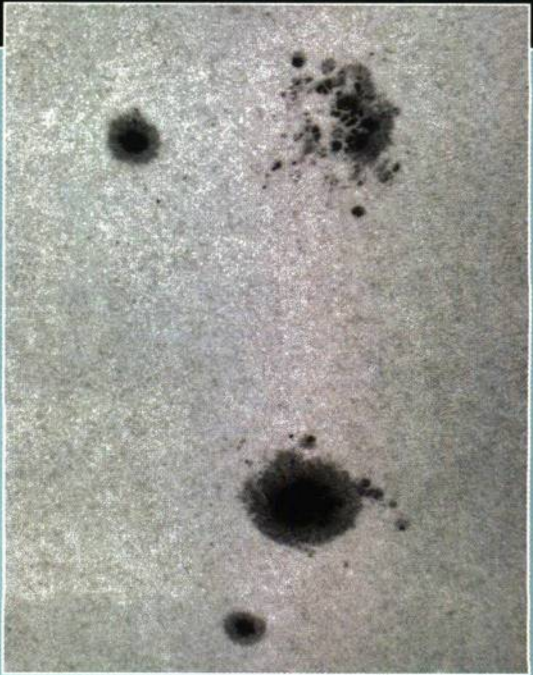
COMET WEST ►
Ronald E. Royer

The best comet of the last 30 years, West was discovered by astronomer Richard West on November 5, 1975, and quickly became a naked-eye object. By the spring of 1976, when Royer photographed it, the comet shone at magnitude –1 and sported a tail several degrees long. It was a startling sight in the morning sky.



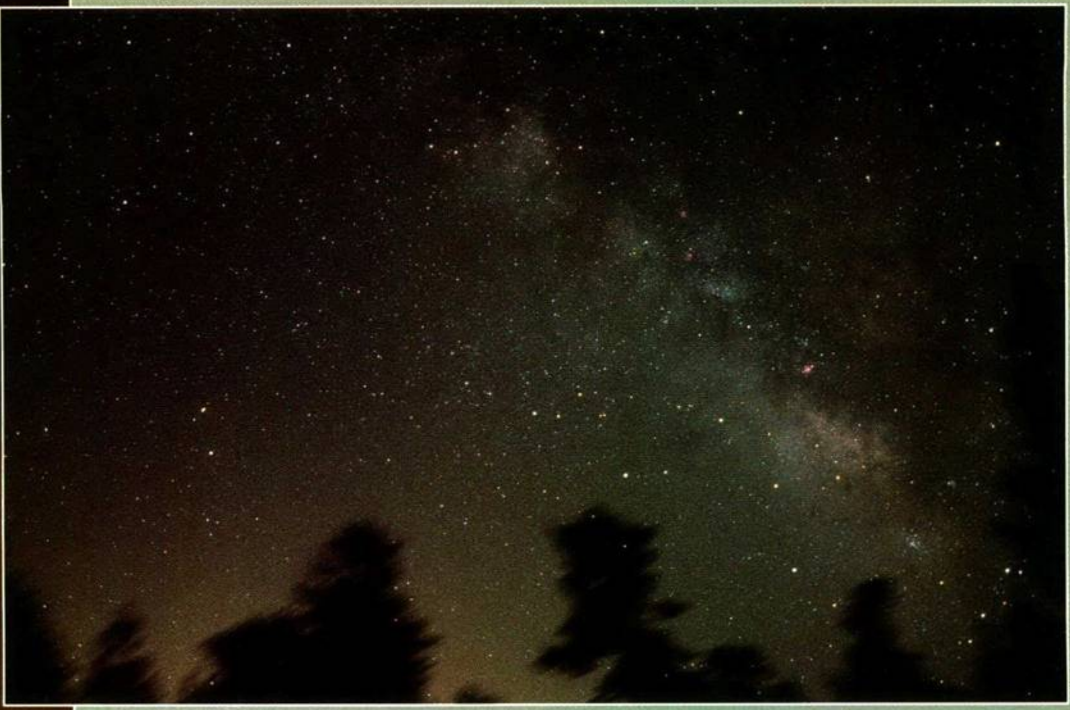
THE MOON'S COPERNICUS REGION ►
Christian Arsidi

Battered by eons of solar system debris, the Moon's surface inspires a feeling for the primitive solar system. Arsidi's high-resolution image shows the prominent crater Copernicus (right center), the ancient crater Stadius (almost obliterated by lava, center), and a chain of small secondary craters from the Copernicus impact (center). Eratosthenes is the prominent crater at lower left.



SUNSPOTS ►
Gerard Therin

Sunspots are tied to the solar wind and its effect on Earth's magnetic field and atmosphere. These cool magnetic storms on the Sun's photosphere wax and wane in an 11-year cycle. Therin's photo is a high-resolution image made with a 4-inch refractor and Tech Pan film.

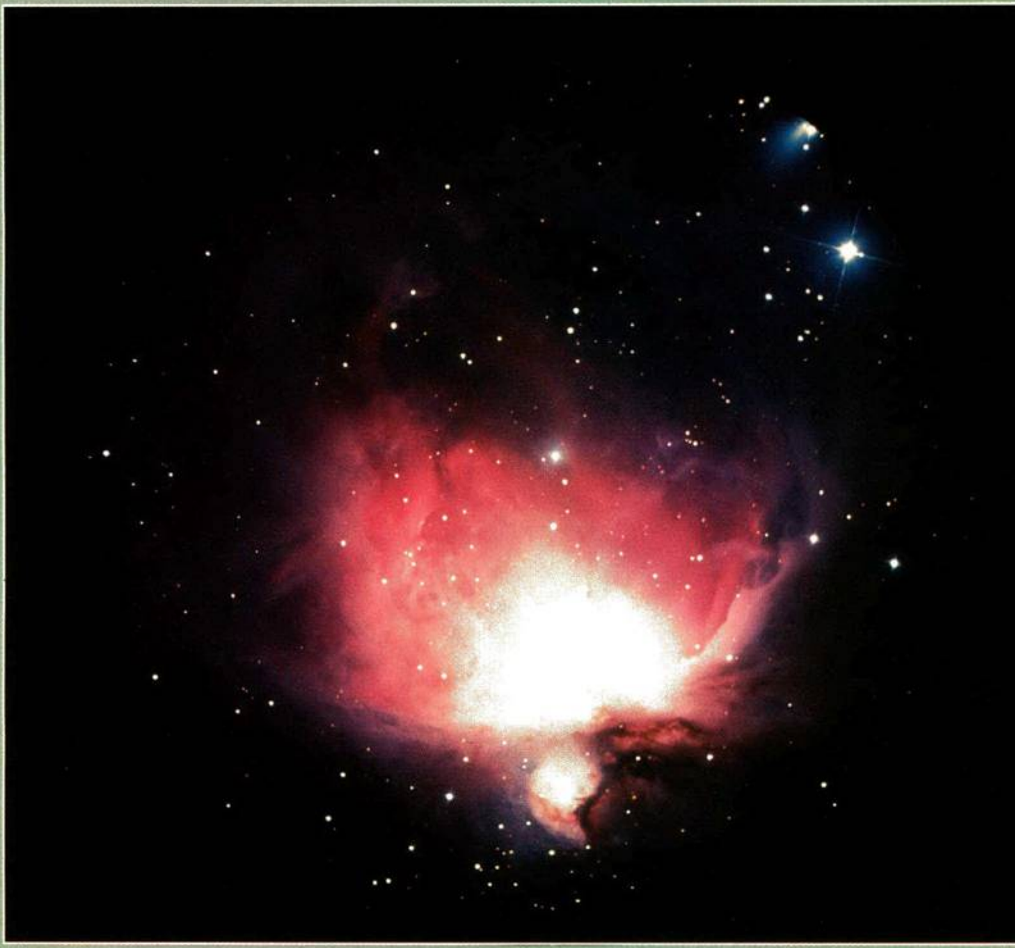


▲ **THE SUMMER MILKY WAY**
David Palmer

Nothing inspires observers like the glow of the summer Milky Way as it arches overhead on a warm night. Palmer's photograph shows the constellations Sagittarius, Scorpius, Scutum, and Aquila. As the camera platform tracked the stars during the exposure, the foreground trees blurred.

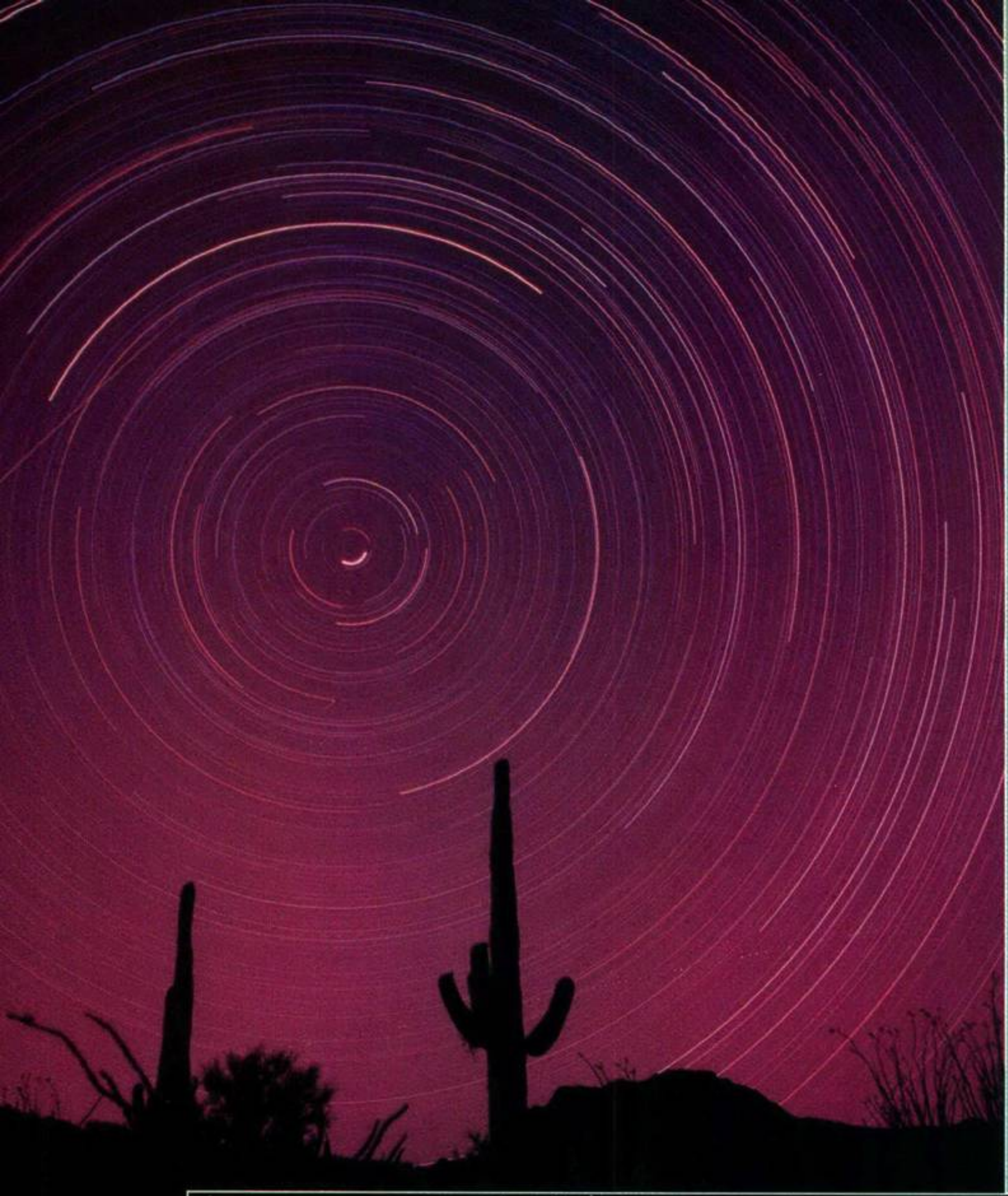
▲ **ANNULAR ECLIPSE OF THE SUN,**
January 4, 1992
Dewey Vanderhoff

A "ring of fire" illuminated the landscape on the fourth day of 1992 as a spectacular annular eclipse swept over coastal California. Vanderhoff recorded the late afternoon scene from Torrey Pines State Park near San Diego.



THE ORION NEBULA ►
Jack Newton

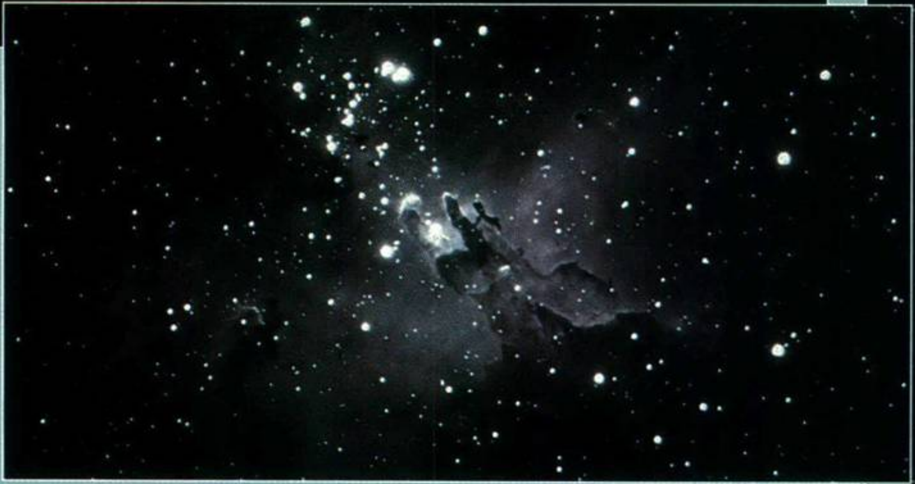
The Orion Nebula (M42) is the brightest, largest, and most spectacular nebula visible to Northern Hemisphere skywatchers. Jack Newton's color portrait of the nebula, made with a 20-inch reflector and a cold camera, shows numerous faint, intricate swirls of nebulosity glowing pink in the light of hydrogen gas.



◄ **STAR TRAILS**

over Sedona, Arizona
Joshua Vaughan

Place a camera on a sturdy tripod, load it with color film, aim it toward the north celestial pole, and open the shutter for a few hours. The result will resemble this striking image by Vaughan: Stars appear to rotate around the pole. The bright arc nearest the pole is Polaris.



▲ **THE EAGLE NEBULA**

Tony and Daphne Hallas

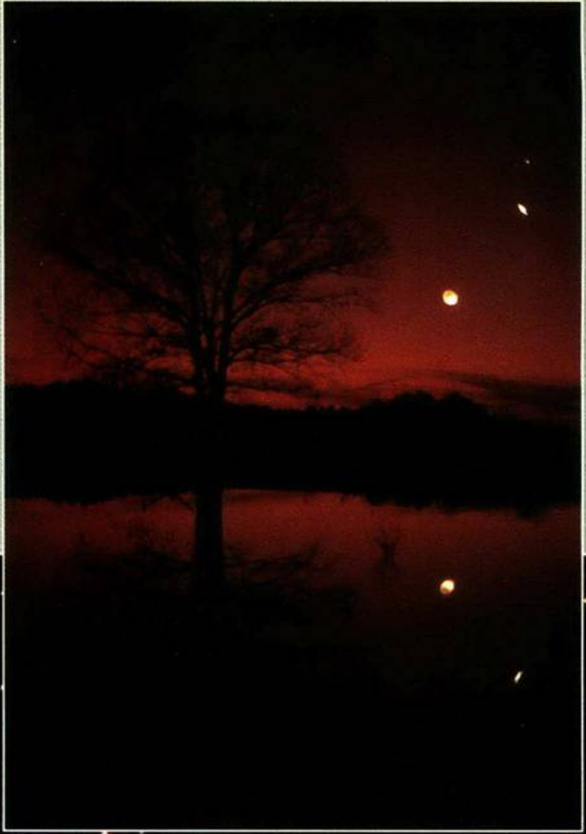
When French comet hunter Charles Messier first catalogued the Eagle Nebula (M16) in Serpens, he called it "a cluster of small stars enmeshed in a faint light." Astronomers now know the Eagle as one of the largest star-forming regions near us in the Milky Way. The Hallas' photo of the Eagle, captured in crisp black and white, shows the star cluster observed by Messier surrounded by extensive nebulosity and dark regions of dust that will collapse into new stars.

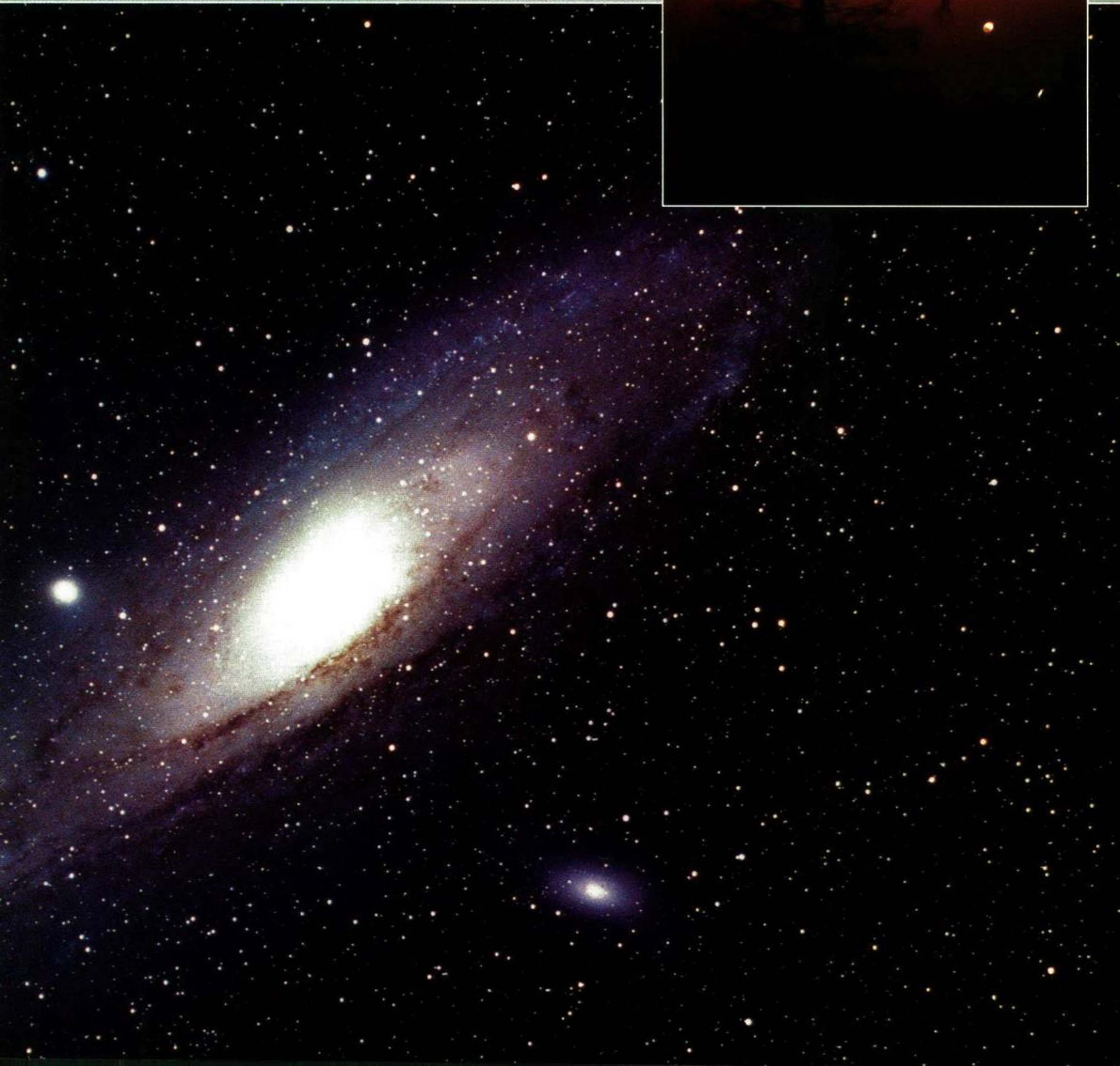
THE ANDROMEDA GALAXY
George Greaney

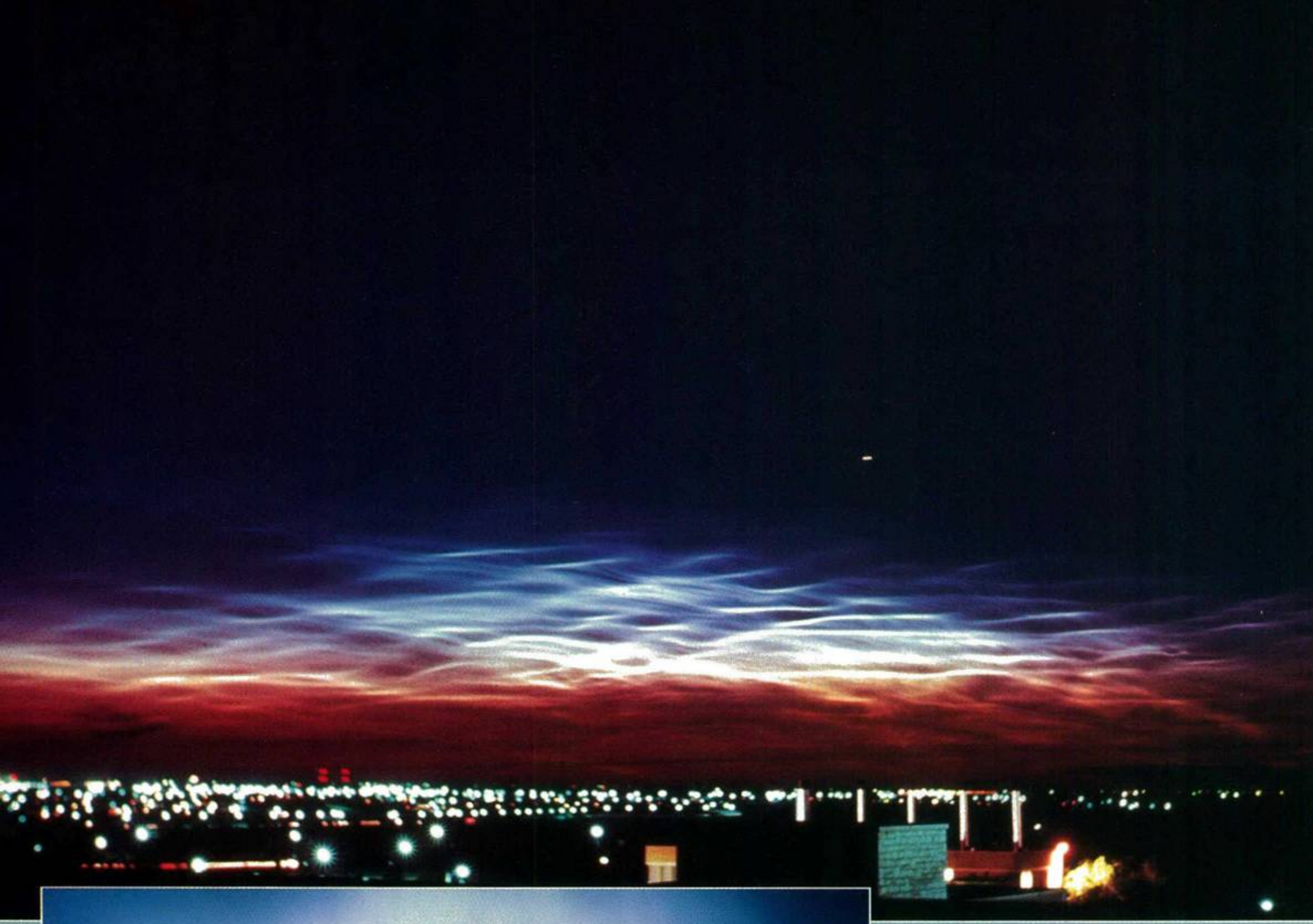
As large in our sky as four Full Moons, the Andromeda Galaxy (M31) is the biggest, brightest, and closest spiral galaxy outside the Milky Way. The galaxy's disk spans more than 100,000 light-years and contains some trillion stars. Greaney's superb color picture, made with a 5-inch refractor and Super HG 400 film, nicely shows both the yellowish hub and bluish spiral arms of the galaxy. ▼

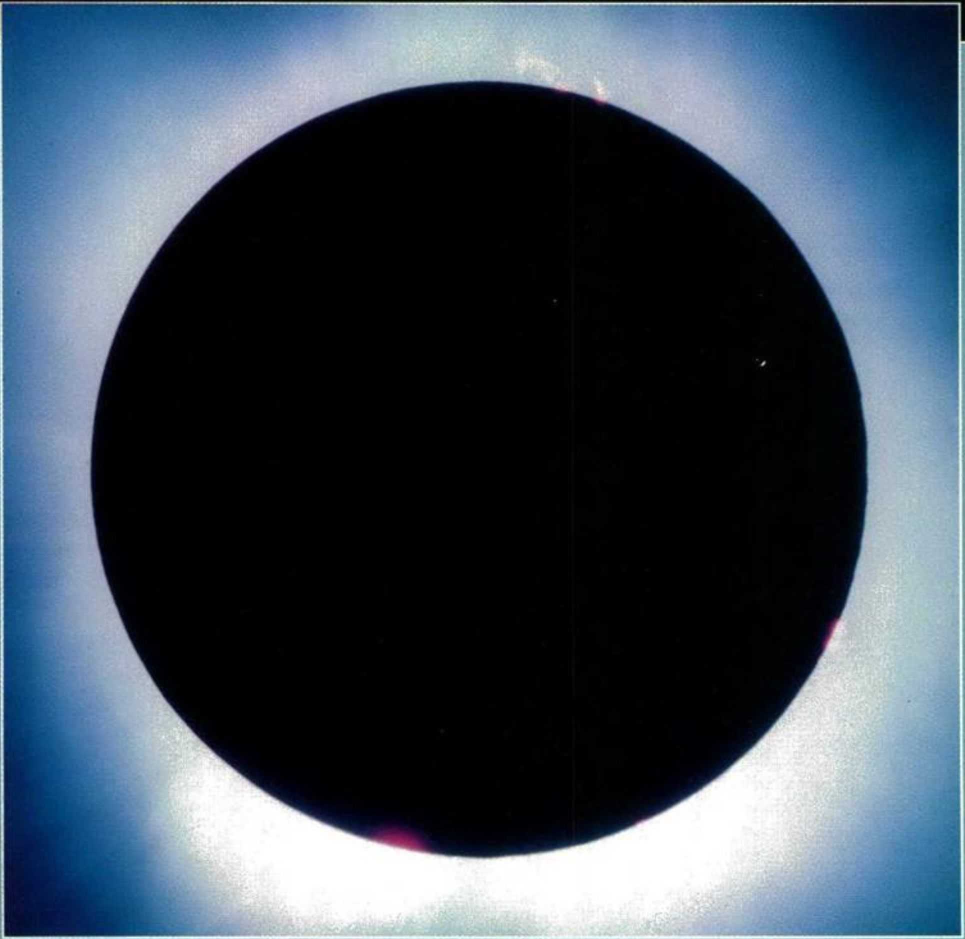
MOON, VENUS, AND MARS ►
over Dixon's Mill, Alabama
Johnny Autery

Planetary groupings in the sky can be the prettiest of all things astronomical. As dusk sweeps over the landscape and otherworldly colors paint the sky, the Moon and planets seem like old friends. In 1984 Autery captured the Moon, Venus, and Mars and their reflections in a pond.







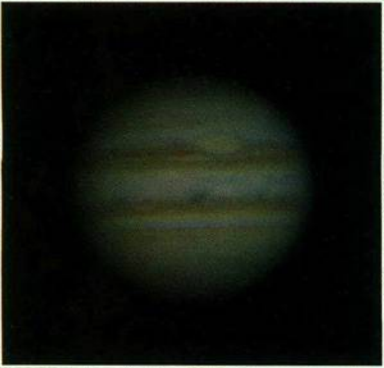


▲ **NOCTILUCENT CLOUDS**
Oscar Van Dongen

Noctilucent clouds form when water vapor penetrates above the stratosphere and freezes into ice crystals. These clouds are so high above Earth's surface — usually about 50 miles up — that they remain sunlit long after sunset. Van Dongen's photo shows an especially bright and colorful noctilucent cloud.

◄ **TOTAL SOLAR ECLIPSE**
July 11, 1991
Scott McGurk

Nothing excites astronomers like a total solar eclipse. The chance incident of nature, when the sky goes dark during the day, attracts skywatchers who travel hundreds or thousands of miles to stand in the Moon's shadow. McGurk's photo, made with a 1000mm lens and Ektar 125 film, shows the eclipse as it appeared from San Jose del Cabo, Baja California, Mexico.



▲ **MARS**
Donald C. Parker

JUPITER
Jean Dragesco

SATURN
Charles F. Capen

Mars, Jupiter, and Saturn are tops for planet watchers. The shifting dark markings and polar caps of the Red Planet, the belts and bands and moonplay of Jupiter, and the entrancing rings of Saturn captivate all who have seen them in the eyepiece. Parker's, *Dragesco's*, and Capen's images of the "big three" planets are among the best ever made by amateurs.

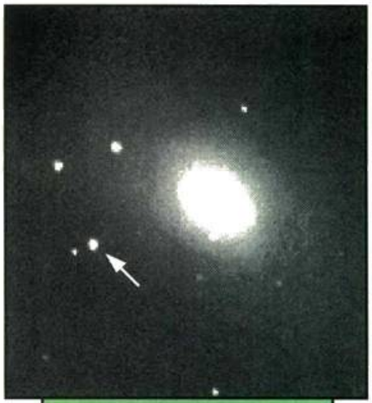
▲ **AURORA** over Edmonton, Alberta, September 24, 1987
Russ Sampson

Our Sun frequently sends bursts of particles from storms on its surface outward into the solar wind. When such a burst reaches Earth, the particles collide with atoms and molecules in our atmosphere and emit a light. We see the event as an aurora, a spooky sky show wherein greenish, red, yellow, or even violet lights can dance around the sky for hours. Sampson's aurora image records brilliant curtains and arcs.

And astrophotography itself has changed dramatically over the past two decades. In the '70s, Tri-X and Kodachrome were the standard films and gas hypering was just beginning to be applied to sky photography. Now much faster color emulsions make photographing the heavens easily reachable so that beginners can produce terrific results. The long apprenticeship of time, film, and money before an astrophotographer "got good" is now pretty much a thing of the past. And hypering is now standard procedure for photographing really faint objects.

Sky events that made good targets for camera and telescope came and went too, leaving a trail of images behind in our collective memory. There were many planetary conjunctions, occultations, eclipses, aurorae, and planetary apparitions. The list reads like a cumulative observing logbook of one person's career as an amateur astronomer, with the recent big events standing out. Certainly the solar eclipse visible from Mexico and Hawaii in 1991, the big auroral show of November 1992, the Martian opposition of 1988, and the appearance of Halley's Comet in 1985/6 are top contenders. And those ever-present deep-sky objects — everyone's photographing those things these days and doing a better and better job of it.

ASTRONOMY will continue its photo-rich reporting of sky events and blanket our pages with reader submissions. These pages contain a tiny sampling of those from the last 20 years. We can't even begin to imagine what the next 20 will bring. One thing is certain. We'll keep on bringing you the best galaxy on the page. □



RECOGNIZE THE INTRUDER? It's the bright star just left of center. CCD image by Michael F. Borman.

READER REPORTS **SPECIAL**

KABOOM!

Supernova in M81

Amateur astronomers enjoy viewing the brightest supernova in six years.

by David J. Eicher

It was a dark and a starry night. Enmeshed in observing galaxies with his 10-inch f/4 reflector, Francisco García of Lugo, Spain, was about to make astronomical history. On the evening of March 28, 1993, García spied a bright star near the central hub of M81 (NGC 3031) in Ursa Major, one of the brightest spirals in the sky. Checking the star against photographs of the galaxy and not finding it in the photos, García contacted astronomers in Madrid who confirmed the interloper as a supernova — potentially the brightest supernova since 1987A, which exploded in the Large Magellanic Cloud. The questions of the hour: Did García catch the supernova "on the rise," enabling astronomers to see the object as it brightened further? What type of supernova was it?

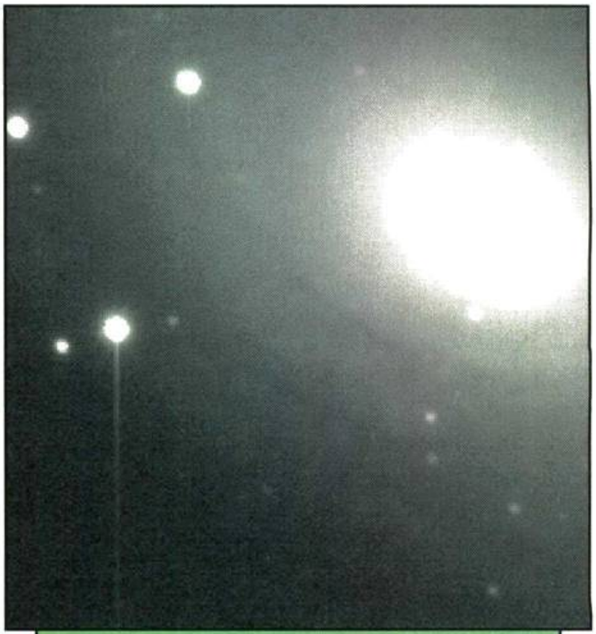
Glowing at magnitude 11.8, the star (now designated SN 1993J) hardly rivaled the supernova in the LMC in brightness. For Northern Hemisphere observers, however, the supernova in M81, a relatively close 10 million light-years away, would be the brightest such object visible in many years.

One day passed. Two days passed. Observations began to converge on the Central Bureau for Astronomical Telegrams in Cambridge, Massachusetts, the clearinghouse for astronomical discoveries. On March 30, Peter Garnavich of the Dominion Astrophysical Observatory obtained spectra that suggested the object was a Type II supernova.

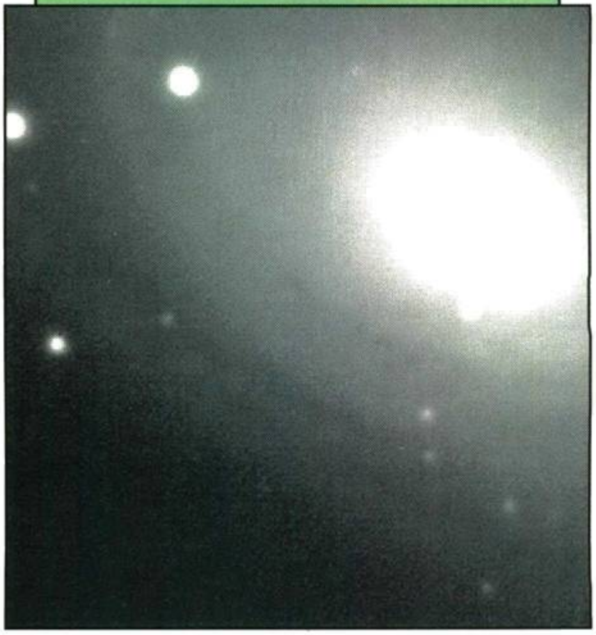
By early April the supernova had brightened to magnitude 10.5 and then slowly faded over the next few days. Curiously, observations showed it brightening again, as supernovae sometimes do, to magnitude 10.9 by mid-April. After this time the star faded substantially and by early May glowed at magnitude 12.

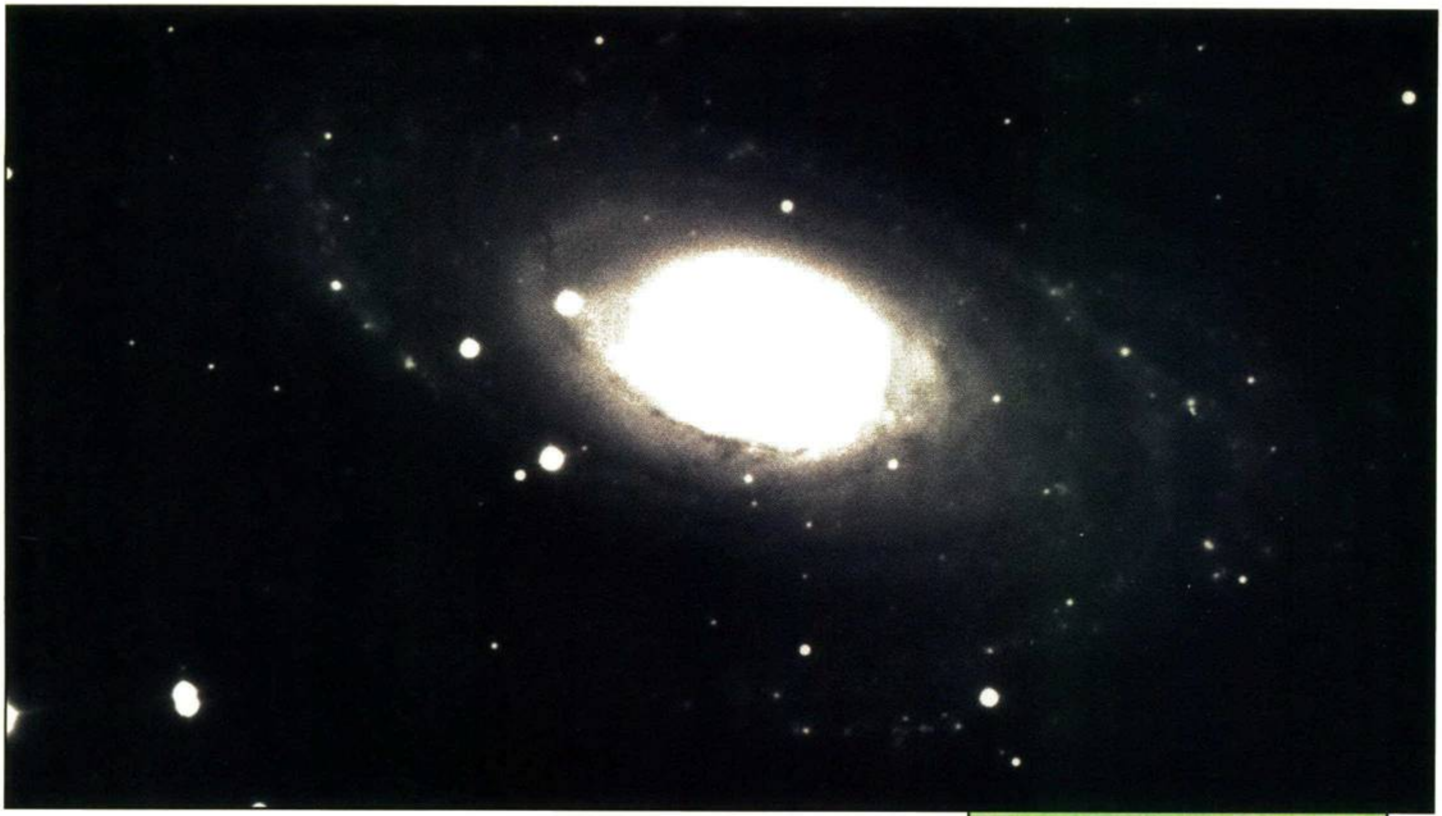
The scenario for a Type II supernova goes something like this: A supergiant star in the galaxy's spiral arm is reaching the end of its life. It is surrounded by a shell of gas puffed off from the star. Incapable of generating energy by fusion to support its own weight, the star collapses, with its core becoming a neutron star. When the star's outer layers crash into the rigid surface of the neutron star, it creates a violent shock wave that explodes material outward. A chain reaction of nuclear processes starts in the superhot, expanding gas. This reaction produces the eruptive event that we see as a star briefly shining as bright as its entire host galaxy.

By mid-April astronomers had confirmed that SN 1993J was a Type II supernova. Backyard observers were already treasuring their memories of the brightest supernova in six years. When will the next be found? □

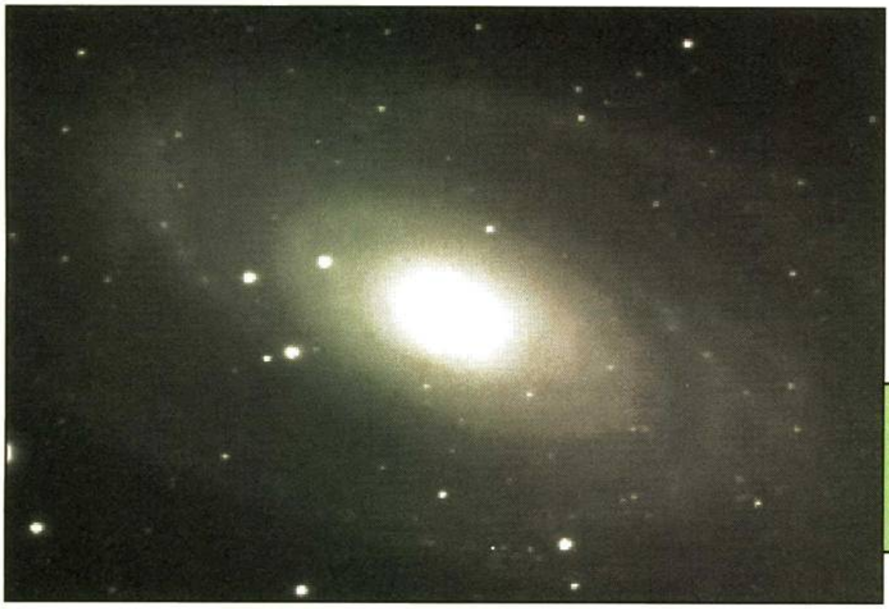


TAKEN TWELVE DAYS APART, these CCD images show M81 with (above) and without its supernova. The top view was made on March 30, 1993, the bottom view on March 18. Images by Ronald W. Kohl.

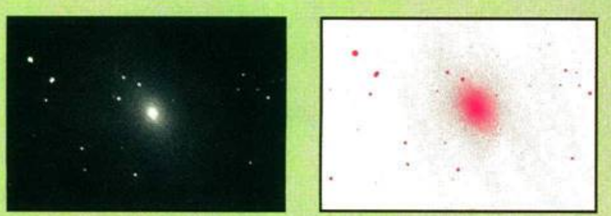


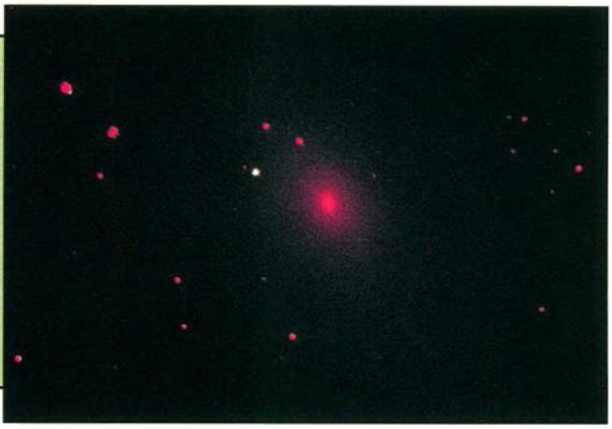


THE SUPERNOVA WANED in brightness in April but still shone as one of the brightest stars around the galaxy. Photo by Kim Zussman.



DELICATE SPIRAL ARMS surround the supernova in this composite CCD image made from five frames. Image by David Hanon.





NOW YOU SEE IT. . . . Now you don't. Hal Jandorf's pair of M81 images shows the galaxy on April 8, 1993, and in early 1990. The image at right is a composite of the two.

ASTRONOMY'S

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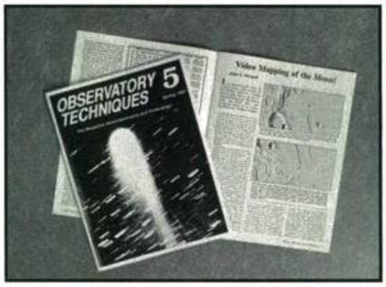
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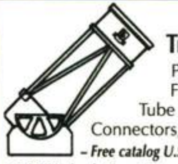
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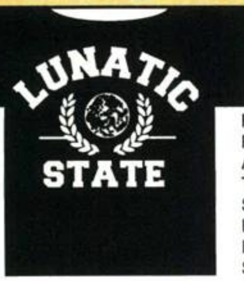

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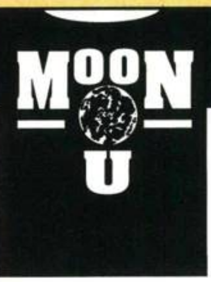

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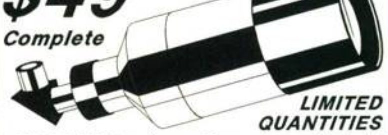

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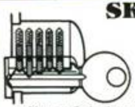

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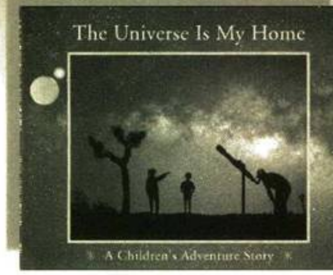

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Stars and Galaxies, edited by David J. Eicher, (AstroMedia, 1992), ISBN 0-913135-05-4, 200 pages, hardcover, $29.95

Stars and Galaxies is a collection of articles about deep-sky observing originally published in Astronomy and written by some of the best-known amateur astronomers in the business — Alan Goldstein, Phil Harrington, David Higgins, Alister Ling, Steve Lucas, and Gregg Thompson, to name a few. It lives up to the quality of other books edited by David Eicher, the founder and former editor of *Deep Sky* magazine.

The book is divided into four major sections. The first describes general deep-sky observing and includes articles on the constellation Orion, the Coma cluster, and exploring the southern sky. The second section covers galaxies, with topics ranging in scope from a single object, the Andromeda Galaxy, to galaxy groups and clusters. The third section deals with double stars and star clusters, including information on winter and southern clusters. The final section is on nebulae, describing bright and dark nebulae, planetaries, and remnants of supernovae.

As with the original articles, photos and sketches lavishly illustrate the text. Finder charts and tables summarize information presented, providing easy reference. At the end of each article there is a short sentence that tells the best time to view the objects discussed in that particular article.

Stars and Galaxies will appeal to a wide audience. It includes basic introductory articles as well as advanced observing pieces. In addition, it presents information on objects in the southern sky frequently overlooked by Northern Hemisphere publishers. Even if you have saved all of your back issues to Astronomy, you'll find *Stars and Galaxies* a convenient reference because it contains all this information in one place. — *Mark J. Coco*

Observing

Celestial Delights, by Francis Reddy and Greg Walz-Chojnacki, (Celestial Arts, 1992), ISBN 0-89087-675-4, 135 pages, softcover, $16.95.

You don't need special equipment to enjoy astronomy; you can explore the sky with your unaided eye. This book will help you learn the constellations and show you where to find the planets between now and 2001. A table of sky events for each year through 2001 highlights eclipses, meteor showers, lunar phases, and planetary conjunctions. Reddy and Walz-Chojnacki also describe eclipses and show the paths for five solar eclipses and the visibility limits for eight lunar eclipses.

Binocular Astronomy, by Craig Crossen with maps and illustrations by Wil Tirion, (Willmann-Bell, Inc., 1992), ISBN 0-943396-36-0, 193 pages, hardcover, $24.95.

This is a detailed binocular observer's guide to deep-sky objects for beginning and experienced astronomers alike. The first chapters explain sky coordinates, introduce the constellations, and tell how to choose binoculars and observe with them. It includes simple observing techniques such as averted vision. Most of the book steps through 57 constellations, organized by the season of the year they are visible. For each constellation, the text describes the bright stars, explains the mythology surrounding the constellation, and highlights deep-sky objects. Many of the object listings also explain what it is you are seeing — how big it is, how far away, and when it formed — to help you better appreciate each object. Charts or photos accompany the selections to aid in locating and identifying the objects. And the book includes Tirion's *Bright Star Atlas 2000.0* to help you navigate around the sky.

Separate chapters describe the Milky Way and some galaxy groups such as the Virgo cluster and the Ursa Major group (including M81 and M82). Rather than use one massive index that would make finding objects in the text difficult, Crossen collected the index into 11 sections, cataloguing references to constellations, asterisms, stars, clusters, nebulae, and galaxies.

Eclipses

Canon of Lunar Eclipses, 1500 B.C. – A.D. 3000, by Bao-Lin Liu and Alan D. Fiala, (Willmann-Bell, Inc., 1992), ISBN 0-943396-37-9, 215 pages, hardcover, $24.95.

Liu and Fiala trace 10,990 lunar eclipses over a period of 4,500 years. Maps with overlays show where each eclipse is (was or will be) visible. Several short introductory chapters describe eclipse phenomena and the methods Liu and Fiala used to calculate the eclipse information in the book. A computerized database containing this eclipse information is also available (see the March AstroBytes). The simple graphical presentation of eclipse visibility makes this a helpful tool for backyard astronomers planning their observations. The consistent physical theory used by the authors also makes this database useful to historians.

Biography

Stephen Hawking: A Life in Science, by Michael White and John Gribbin, (Dutton, 1992), ISBN 0-525-93447-2, 304 pages, hardcover, $23.

Hawking is one of the greatest physicists of this era and perhaps of all time. White and Gribbin give some insight into him as a person, as they detail his life from birth to the creation of the film version of his book, *A Brief History of Time*. They recount his early years in school as an average student and his later successes in physics, including his legendary bet with Kip Thorne over the nature of Cygnus X-1. The book is not solely a biography: It also describes Hawking's ideas about black holes and cosmology.

The Sun

Guide to the Sun, by Kenneth J. H. Phillips, (Cambridge University Press, 1992), ISBN 0-521-39483-X, 386 pages, hardcover, $29.95.

Although this book has a short description of how to observe the Sun, it is primarily a text about the physical characteristics of our star. The sometimes technical, but not mathematical, discussion covers the Sun's structure from the core to the outer atmosphere, or corona. Phillips also describes solar energy, the sunspot cycle, the Sun as a star, and the effects of the Sun on the solar system.

Other Books Received

The Universe . . . and Beyond, Terence Dickinson, (Camden House, 1992), ISBN 0-921820-53-4, 156 pages, acid-free paper, softcover, $22.95. Dickinson has completely updated his tour of the universe for non-scientists. More than 100 full-color photographs and illustrations accompany the text. □

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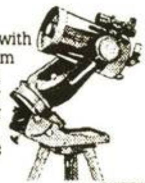

8 inch 2032mm F/10 optical tube with **Starbright** coatings, PEC drive system with hand controller, 30mm Plossl & 7mm Ortho eyepieces, 8x50 Polar illuminated finderscope, 1¼" Star Diagonal, case, wedge & rubberized tripod

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NGF-3. Same as NGF-2 except four stainless steel bearings are replaced with brass. This adds friction to tube, allowing lift of over 2.5 lbs. of accessories. Great for Dobs. $145.00 ($3)

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NEW!

ACCESSORIES:

MOTOFOCUS for NGF-1 through NGF-4, $98.50. ***SAVE $28.50!*** Place order for MOTOFOCUS in combination with focuser and reduce MOTOFOCUS price to just $70.00.

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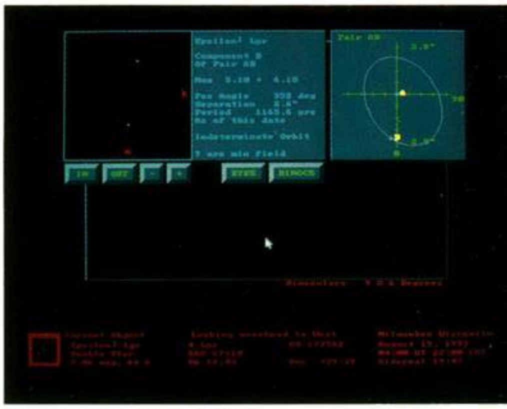

ASTRONOMY: photos by Darla Gawelski

***PC-Sky**, CapellaSoft, P.O. Box 3964, La Mesa, CA 91944. Phone: (800) 827-8265. Price: $99 plus $5 shipping. Minimum requirements: 80286-based computer, 530 KB of free memory, DOS 3.3, VGA display, and a hard drive with 3.2 MB free. A mouse and coprocessor are optional.*

PC-Sky is a new type of program called a sky simulator. It doesn't plot constellation lines, names, or boundaries nor does it print sky maps. It still plots stars and deep-sky objects, but any similarity to a planetarium-type program stops there. Instead you will find PC-Sky presents a novel approach to visualizing the sky.

In this program, galaxies, nebulae, and star clusters look fuzzy, just like they do in the real sky. Clicking on an object brings up a binocular view (9° by 6° field), again with realistic views of faint, fuzzy objects. Wide double stars begin to split through the "binoculars." Another click of the mouse button presents the telescopic view. You can choose from a 6-inch to a 24-inch scope and zoom in as if you had changed eyepieces. The 6-inch scope field zooms from 1° to 1' and the 24-inch scope field zooms from 17' to 20". Close doubles split into component stars, open star clusters reveal their structure, and galaxies and nebulae glow faintly, showing their orientation in the sky.

Forming the database are nearly 27,000 single, double, and variable stars down to magnitude 7.5 and 200 galaxies, nebulae, and star clusters. In selected telescopic fields, the program shows stars down to 16th magnitude. You can add up to 800 more objects (user-added objects all appear as stars).

Moving the cursor to an object in the unaided-eye mode gives information about its brightness, alternate names, and right ascension and declination. In the telescopic view, an information box describes the object. For binary stars a plot also appears showing the orbit with the present separation and position angle marked. For variable stars, a light curve shows how the star's brightness changes with time. Telescopic views of planets show their phase, the rings of Saturn, and satellites of Mars, Jupiter, Saturn, Uranus, and Neptune. However, no features become visible as you zoom in on a planet's surface. A time-step feature lets you follow Moon phases, binary star orbits, the changing brightness of variables, planetary satellite motions, the changing inclination of Saturn's rings, and other sky happenings.

Finding an object is easy. If the object appears in the sky window, you can use "find" to locate it using its common name or its Bayer or Flamsteed designation or its NGC, SAO, HD, or Messier catalog number. "Owl" finds the planetary nebula in Ursa Major and tells you it is also called M97 (but gives no NGC number). Or you can use "lookup," which will tell you the object's right ascension and declination, altitude and azimuth, and rise, transit, and set times. The latter set of times will help you reset the scenario to the proper time to view the object. If the object is already visible at the time presently set, a "find" button pops up to make locating it even easier.

The location database has lots of cities, observatories, and national parks. And it's pretty smart too — "Zimbabwe" found the first city in that country (Bulawayo) and "louis" found East St. Louis in Illinois. It doesn't have a list of locations for scrolling through different possibilities.

Double and variable star observers will find this is the first commercial program to provide both textual and graphical information about thousands of their favorite objects. PC-Sky will help beginning observers better understand what they'll really see through their binoculars and telescopes and help them plan star-hopping paths. And many experienced observers may find they prefer this display format to the atlaslike appearance of many planetarium programs. — *Dave Bruning*

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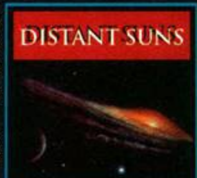

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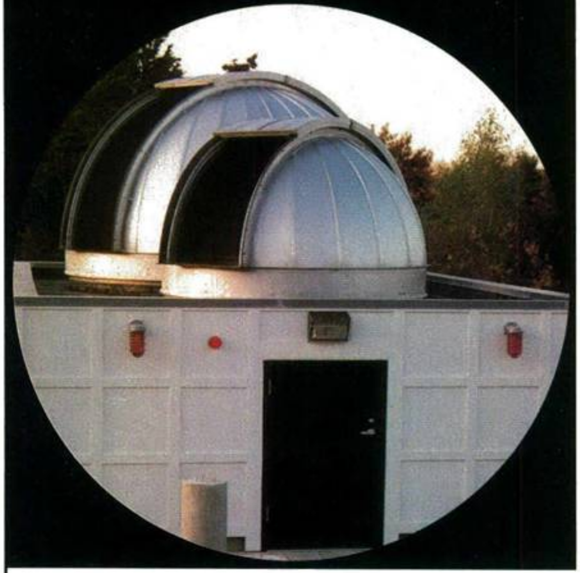

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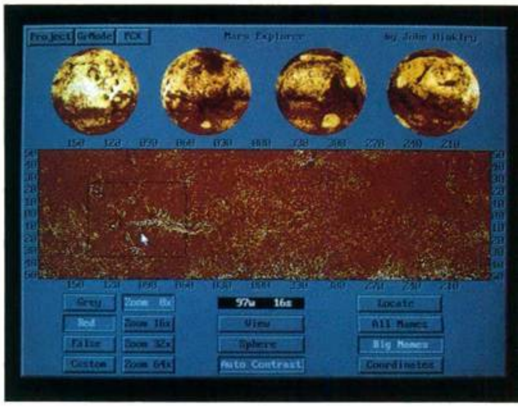

Mars Explorer, *Virtual Reality Laboratories, Inc., 2341 Ganador Court, San Luis Obispo, CA 93401. Phone: (805) 545-8515. Price: $69.95. Minimum requirements: 80386-based computer, 4 MB memory, DOS 3.0, VGA display, mouse, and CD-ROM drive.*

Humans won't set foot on Mars until sometime in the next century, but you can explore Mars now with this CD-ROM and software. Over 200 MB of Viking spacecraft images bring Mars to your computer screen, letting you explore in detail the Red Planet's surface, its volcanoes, craters, and valleys, with the simple point and click of a mouse.

You can display the images in shades of gray, red, or false-color. Four levels of zoom reveal details smaller than 2 kilometers across. To display a part of the surface, you can either use the mouse to point to a section of a map or a list to find a feature by name. You can select labels to add to an image, add coordinate lines, adjust the image's contrast and brightness (or let the computer do it for you), and scroll the screen to nearby features. After modifying the image, you can save it as a PCX-format file for use in other programs.

A spherical Mars lets you see what the various albedo features look like as the planet rotates. I wish this feature would display the central meridian so it would be easier to compare with observations. An appendix in the manual translates feature names for you, telling you that *colles* means small hill and a *patera* is a shallow crater.

Mars Explorer is a delight to use and provides an excellent guide to the Martian surface. Planetary observers, image junkies, and armchair astronomers will love exploring Mars through this rich set of images. — *Dave Bruning*

(continued on page 106)

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NEW SOFTWARE

TideMaster*, Zephyr Software, 1900 Murray Avenue, Pittsburgh, PA 15217. Phone (800) 533-6666. Price: $39.95 per coastal state, plus $4 for shipping and handling. Minimum requirements: IBM PC-compatible computer and Hercules or CGA display.*

TideMaster provides levels and times for high and low tides. Just select a time and a location and information about local tides will appear in either table or graphical form. You can print out the tables or graphs onto a dot-matrix or laser printer. Or you can print a reduced version that fits three months of data onto a page so you can keep it in your wallet (requires a dot-matrix printer).

Tide information is available for the Bahamas and all coastal states except Hawaii and Alaska. The program uses National Oceanic and Atmospheric Administration data for over 2,000 shore and river inlet locations. Annual upgrades are available for a small fee.

TheSky for Windows (version 1.1)*, Software Bisque, 912 Twelfth Street, Suite A, Golden, CO 80401. Phone: (303) 278-4478. Price: Level II, $129; Level III, $199. Minimum requirements: 80286-based computer, 640 KB memory plus 512 KB extended memory, DOS 3.1, and Windows 3.X. A mouse and a coprocessor are recommended.*

The latest version of TheSky (previously called The_Sky; see the May and July AstroBytes) has several new features. A tutorial book accompanies the manual, describing basic astronomy concepts. Meade LX200 and Jim's Mobile SGT-Max telescope support are available as options (contact Software Bisque for other telescope support). A chart mode allows you to produce atlas-style maps and a night-vision mode colors the screen red for use at the telescope. You can view the planets from any angle in the three-dimensional solar system simulator. A print button now makes printing maps faster and the event animation feature can record events for later playback. The slideshow feature steps through 102 images of the planets and deep-sky objects provided with the software at an adjustable rate, with or without labels — a great idea for public presentations. You can also add your own GIF-format images. And you can now export maps as a Windows metafile (*.WMF) for use in other Windows programs.

Distant Suns for Macintosh*, Virtual Reality Laboratories, Inc., 2341 Ganador Court, San Luis Obispo, CA 93401. Phone: (805) 545-8515. Price: $99.95. Minimum requirements: 2 MB of memory, System 6.0.2, and 3.6 MB free on hard disk. Macintosh II, math coprocessor, and a 256-color system are recommended.*

This PC and Amiga planetarium-type program is now available for Macintosh users. It displays 9,824 stars and almost 2,000 galaxies, nebulae, and star clusters. Additional files are available from Virtual Reality to expand the stellar database. You can enter any date from 4713 B.C. to A.D. 10,000. You can display comets and asteroids, produce star charts, show animations of eclipses, plan observing sessions, and search for stars by SAO or HD catalog numbers. Twenty-four images come with the software and you can add your own PICT-format images. Distant Suns lets you customize your control panel so you can easily access the buttons you use most often or even add your own.

Time Service Available on Internet

Computer users can now access precise time standards from the Internet computer network. You can obtain software and documentation for the "daytime" protocol via anonymous ftp at TIME_A.TIMEFRQ.BLDRDOC.GOV (requires no password or account). For more information, send an e-mail request to TIME@TIME_A.TIMEFREQ.BLDRDOC.GOV or write Network Time Service, NIST, Division 847, 325 Broadway, Boulder, CO 80303-3328.

CalMaster 2000*, Zephyr Software, 1900 Murray Avenue, Pittsburgh, PA 15217. Phone (800) 533-6666. Price: $49.95, plus $4 for shipping and handling. Minimum requirements: IBM PC-compatible computer and VGA display.*

Archaeoastronomers and others needing to switch between calendrical systems will find CalMaster 2000 helpful. It will convert dates up to A.D. 3000 to any of 14 systems: Julian, Gregorian, Jewish (Talmudic), Hebrew, Muslim (tabular), Chinese (old and modern), Japanese (old Kigen and new Meiji), Sothic, Coptic, Nabonassaran, Amenhotep I, and Senwosret III. The calendars include holidays, feast days, and historical events. U.S., Canadian, British, and international versions of the Gregorian calendar reflect the different holidays. You can add personal notes to individual days and print the calendar on dot-matrix or laser printers. □

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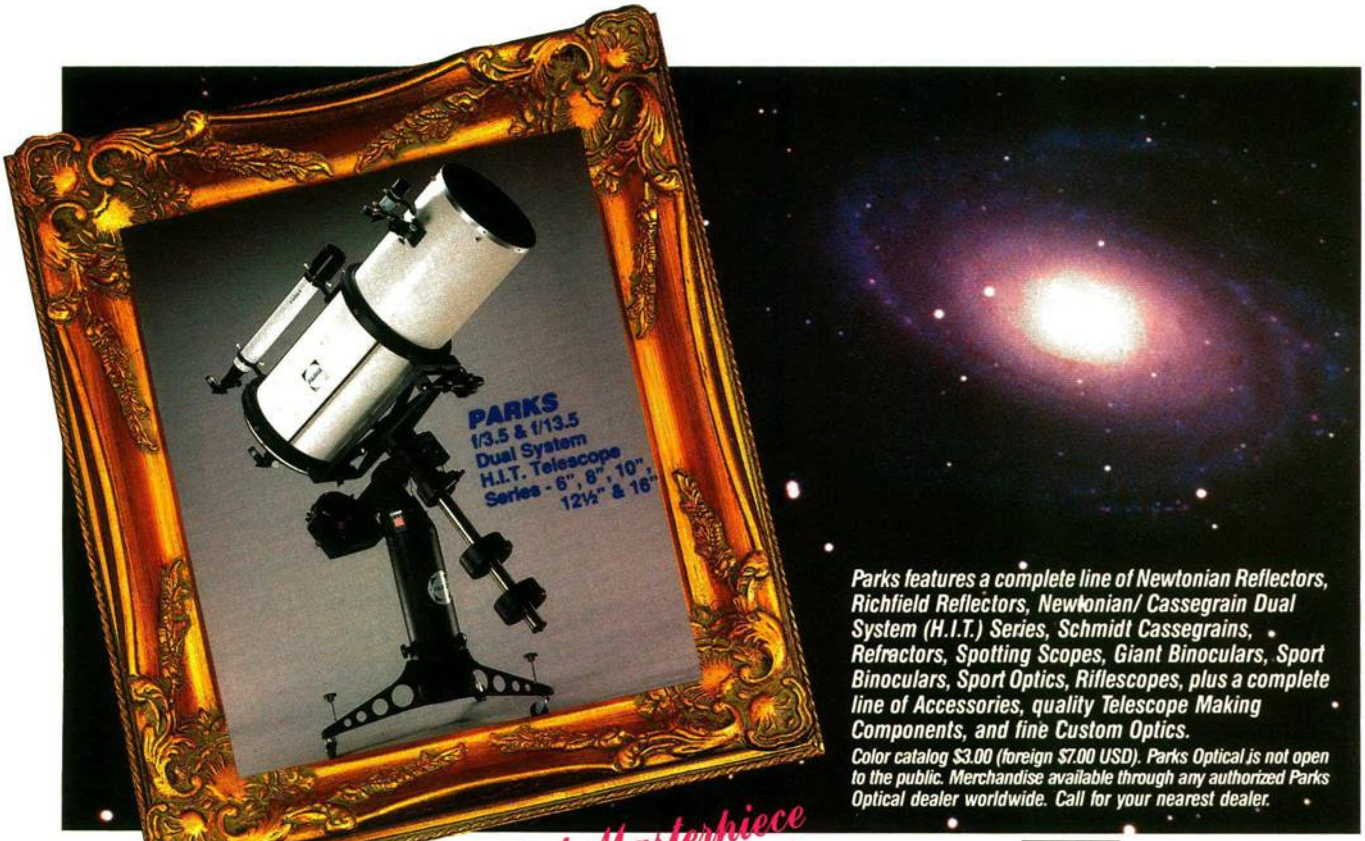

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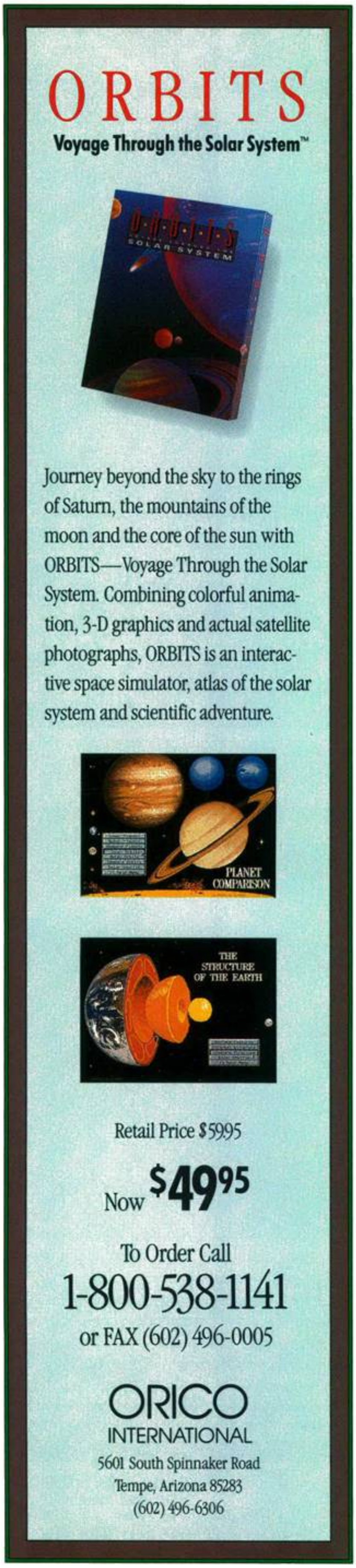

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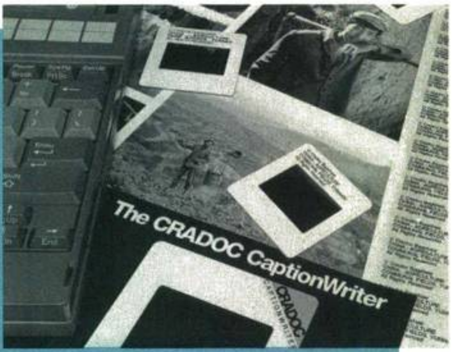
New Astronomy Products

1 Genesis SDF Refractor

Replacing the popular Genesis telescope, the new Genesis SDF features "special dispersion" glasses for the two front elements. Combined with the rear fluorite element, the design provides extended color correction. The 4-inch f/5.4 refractor also produces a flat field for photography (with a 2.5° by 3.8° field on a 35mm frame), and up to a 4.9°-wide field with low-power eyepieces. The telescope includes a mounting ring with three 1/4-20 tapped holes for securing the tube assembly to a tripod or telescope mount, a 2-inch diagonal, 1.25-inch adapter, 17mm Plössl eyepiece, sliding dew shield, threaded lens cover, and hardshell case. The tube assembly weighs 11 pounds and is 33 inches long. The Tele Vue altazimuth Gibraltar mount and Starbeam finder shown are available as options.

Tele Vue, 100 Route 59, Suffern, NY 10901, (914) 357-9522. $2,595.



2 Slide Labeling Software

Of interest to astrophotographers, the CRADOC CaptionWriter is a slide labeling program for computers. The program automatically prints the photographer's name and copyright information, a sequential number, and specific caption information on a label with up to five lines of information per label. The CaptionWriter is available in versions for both IBM and Macintosh computers.

CRADOC CaptionWriter, Perfect Niche Software, Inc., 6962 E. First Avenue, Suite 103, Scottsdale, AZ 85251, (602) 945-2001. $69.95, for either Mac or PC versions.

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3 New Economical Eyepieces

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Royal Optics, 20 Glassco Avenue South, Hamilton, Ontario, Canada L8H 1B3. (U.S.) $39 each; (Can.) $55 each.

4 New Products from Learning Technologies

A Spectrum Projector is now available as part of Learning Technologies' Project STAR hands-on science materials. The kit provides all the materials necessary to build a device that will project a spectrum of an incandescent light source across a room for group viewing. Learning Technologies has also released a free Starlab Educator's Directory which lists users of the inflatable Starlab planetarium.

Learning Technologies, Inc., 59 Walden Street, Cambridge, MA 02140, (800) 537-8703. Spectrum Projector: $75 plus shipping.

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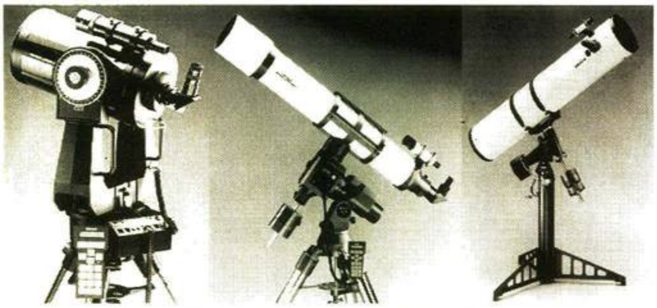

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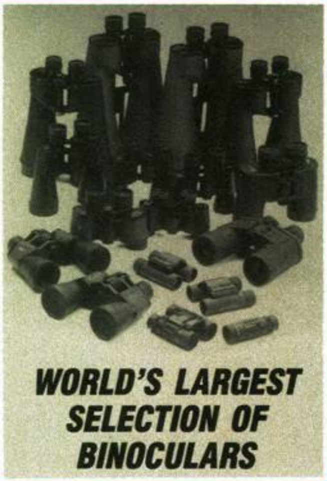

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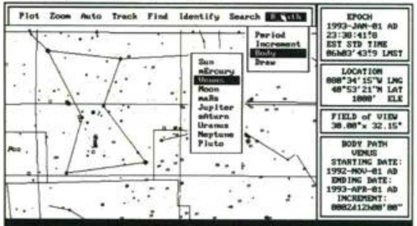

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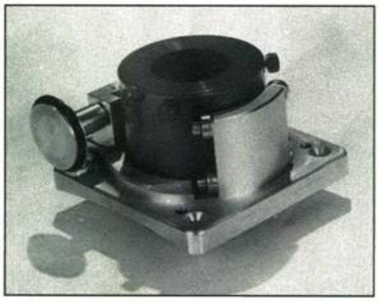


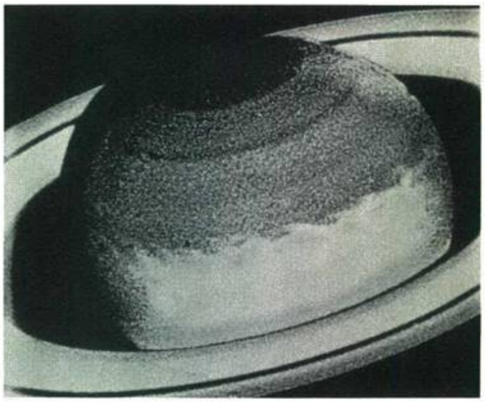
6 Low-Cost Focusers from JMI

The NGF-3 and NGF-4 are both Crayford-style "zero-image-shift" focusers that use a new low-friction bearing material in place of the sealed stainless steel ball bearings used in the premium NGF-1 and NGF-2 focusers. The low-cost models have a reduced lifting capacity — 2.5 pounds versus 5 pounds for the premium focusers. The NGF-3 is black anodized. The NGF-4 is finished in natural aluminum and has only one focusing knob. Both accept 2-inch eyepieces.

Jim's Mobile Inc., 810 Quail Street, Unit E, Lakewood, CO 80215, (303) 233-5353, FAX (303) 233-5359. NGF-3: $139 (includes 1.25-inch adapter); NGF-4: $98.50 (1.25-inch adapter: $19.95).

7 New Slide Sets from the ASP

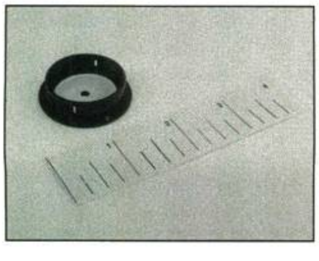
The Hubble Space Telescope Set #2 includes 20 new images from Hubble accompanied by a 16-page explanatory booklet. The Women in Astronomy set features 26 slides and a 36-page booklet describing the important role women have played and are playing in astronomy. An updated version of the Worlds in Comparison slide set includes a 20-page booklet and 20 slides contrasting the sizes of planets and their geologic features.



The Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112. Hubble Space Telescope Set #2: $29.95; Women in Astronomy: $39.95; Worlds in Comparison: $29.95. Outside the United States, please add $6 for shipping and remit in U.S. funds.

8 The "Aline" Alignment Eyepiece

Simple in design, the Aline accessory aids in collimating your Newtonian telescope. It uses an ultra-reflective material and light gathered by the telescope to produce an image Rigel claims to be much brighter than images obtained with some competing alignment eyepieces that let in light through a hole in the side of the tube. Look into the Aline and you see a bright white circle surrounding the image of your eye's pupil, facilitating centering of the primary and secondary mirrors. The Aline fits 1.25-inch focusers.



Rigel Systems, 26850 Basswood Avenue, Rancho Palos Verdes, CA 90274, (310) 375-4149. $4.99 plus $1 shipping.

FOR SALE — 20" roller bearings on polar and declination axes. Slew and tracking rates on polar axis, 24" worm. Weighs approximately 800 lbs. $4,500 firm, you pay shipping. Serious inquiries only please. Contact Ray Grenman, 10978 Rocky Road, Bent Mountain, VA 24059. Phone (703) 929-4872 or (703) 929-4405.

WANTED — Correspondence worldwide with persons interested in astronomy, micro/macro cosmos, theology, or music. Contact Dean Westwood, Perry Road, H.M.P., Sherwood, Nottingham, NG5 3AG England.

FOR SALE — ASTRONOMY (1982-1986, some missing); Newtonian reflector, 4¼" motor drive. Make offer. Contact Tony Davis, 182 Oak Grove Road, Blacksburg, SC 29702. Phone (803) 839-6734.

FOR SALE — SP/C8 with extras, almost mint. $1,000 firm. Contact David Blain, 1512 S. Gail, Monahans, TX 79756. Phone (915) 943-6543.

FOR SALE — Odyssey 8 with a Dobsonian mount, 2 eyepieces. Like new. Contact Charles Schrock. Phone (513) 464-7702 days, or (513) 464-7093 evenings.

FOR SALE — Fourteen-year old seeks worldwide correspondence with persons interested in astronomy and paleontology. Contact Ann McManus, 780 Pelham Parkway South #A6, Bronx, NY 10462-1108.

FOR SALE — New 6" f/15 Cheshire refractor, optical tube, and finderscope. $4,000. Contact William Hopper, 1215 Waugoo Avenue, Oshkosh, WI 54901. Phone (414) 235-0693.

FOR SALE — Sixteen-year-old astronomy beginner wants to hear from other astronomers living in Puerto Rico or around the globe. My interests include computers and CCD imaging. Contact Ronald Flores, Alta Vista, 16 #0-10, Ponce, Puerto Rico 00731.

FOR SALE — Twenty-five-year-old male interested in particle physics, cosmology, and mathematics, seeks correspondence with those serious about physics and mathematics. Contact Deepak Sainju, c/o Roshan Shrestha, Korean Air, P.O. Box 939, Kathmandu, Nepal.

FOR SALE — Thirteen-year-old male seeks correspondence with anyone interested in astronomy. Contact Steven Headley, Jr., 538 Prairie Drive, Wichita, KS 67230-9323.

FOR SALE — ASTRONOMY (1973-1982) and December 1985 issue; *Deep Sky* (1-19); *Telescope Making* (1-30); *Sky & Telescope* (1941-1962) and any out-of-print atlases (moon, sky, objects). Contact Andreas and Sabine Phillip, Heerweg 15, D-78595 Hausen ob Verena, Germany.

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Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
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4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
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10"	109.00	10"	99.00
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14"	169.00	14"	149.00

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Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
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8"	125.00	8"	109.00
10"	139.00	10"	119.00
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10 John Dobson Telescope-Making Video

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11 Lanthanum Binoculars from Cosmos

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Cosmos Ltd., 9215 Waukegan Road, Morton Grove, IL 60053, (800) 643-2351. 7x42: $279; 10x42: $297; 8x24: $117.

12 Blue Planet IMAX Film on Video

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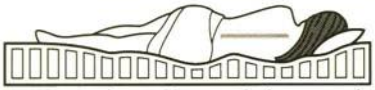

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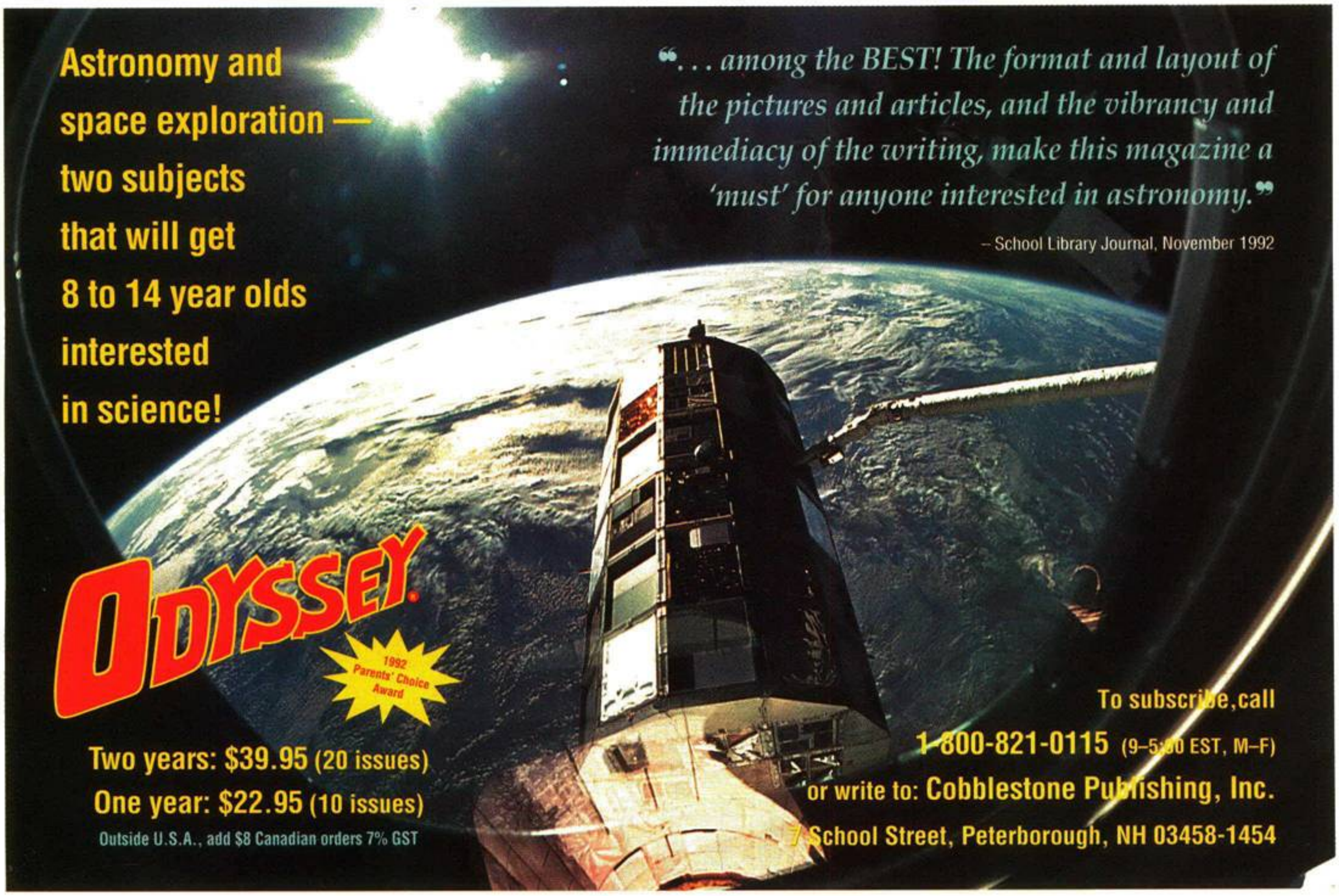

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Readings & Credits

Big Scopes: Dawn of a New Era
(page 48)

"Seeing A Brave New World," by Joel Harris, ASTRONOMY, August 1992. Describes in detail the Keck telescope and its unusual segmented mirror.

Celestial Events of the Future (page 64)

Astronomical Tables of the Sun, Moon, and Planets, by Jan Meeus (Willmann-Bell, Inc., 1983). A comprehensive reference work providing data on many types of celestial events past, present, and future.

Deep-Sky Summer: The Milky Way
(page 70)

Stars and Galaxies; ASTRONOMY's *Guide to Exploring the Cosmos*, edited by David J. Eicher (Kalmbach Books, 1992). Articles from ASTRONOMY take readers on a tour of 400 deep-sky objects.

Gearing up for the Perseids (page 76)

Meteor Showers: A Descriptive Catalog, by Gary W. Kronk (Enslow Publishers, 1988). The text summarizes attributes of many meteor showers. The Perseids are covered in seven pages.

Kaboom! Supernova in M81 (page 92)

The Supernova Search Charts and Handbook, by Gregg D. Thompson and James T. Bryan, Jr. (Cambridge University Press, 1988). Includes charts for observing and finding supernovae in more than 300 galaxies.

The Supernova Story, by Laurence A. Marschall (Plenum, 1988). A general account of supernovae — how they occur, and how astronomers analyze them.

Cover: NASA artwork by Pat Rawlings/SAIC; ***p. 4:*** ©1993 Sehgal Corp. and Jack Newton, 25-inch f/5 Newtonian, SBIG ST-6 CCD camera; ***p. 18, left:*** Richard Schwartz and NASA; ***right:*** Jane Luu/University of California at Berkeley; ***p. 19, top:*** NASA; ***left:*** California Association for Research in Astronomy; ***right:*** NASA; ***p. 20, top:*** Bill Latter/NRAO; ***bottom:*** M.N. Hintzen, E.P. Smith, K.-P. Cheng; ***p. 24:*** NASA; ***p. 26:*** Reginald Dufour/Rice University, courtesy Dave Van Buren; ***p. 29, left and right:*** Darla Gawelski; ***p. 33:*** NASA; ***p. 34:*** USGS; ***p. 37:*** Anglo-Australian Telescope Board; ***pp. 38-39:*** Uwe Keller, Max-Planck-Institut für Aeronomie; ***p. 41:*** NASA/JPL; ***p. 43:*** Michael Carroll; ***p. 44:*** NASA/JPL; ***p. 47:*** NASA artwork by Pat Rawlings/SAIC; ***pp. 48-49:*** courtesy of the California Association for Research in Astronomy; ***p. 50, top left:*** courtesy of UA Steward Observatory; ***middle left:*** courtesy Schott Glaswerke; ***middle right:*** courtesy of Corning, Inc.; ***bottom:*** courtesy of Howard Lester; ***p. 51, top:*** courtesy of the Observatories of the Carnegie Institution of Washington; ***bottom:*** courtesy of the University of Arizona; ***p. 52, top:*** courtesy of the National Astronomical Observatory of Japan; ***bottom left:*** courtesy of the Gemini Project, AURA; ***right:*** courtesy of Apache Point Observatory; ***p. 53, top:*** courtesy of the University of Texas; ***bottom:*** courtesy of Dan Long, University of Chicago; ***p. 56:*** Stephen Keene, 31-inch Newtonian with an 11.5-inch mask, Fujichrome 100 film, 7-second exposure, October 22, 1992; ***p. 59, top:*** Gérard Therin, 9-inch f/12 SCT at f/95, hypered Tech Pan film, 5.5-second exposure with a yellow filter, August 7, 1992; ***bottom:*** Lunar and Planetary Lab, August 30, 1969; ***p. 70, top:*** Christopher Galfo; ***bottom left:*** Jack Newton; ***bottom right:*** Jack Marling, 24-inch f/15 Cassegrain, Fujichrome 400 film, 20-minute exposure; ***p. 71:*** Michael Stecker; ***p. 72 , top:*** Tony and Daphne Hallas; ***bottom:*** Michael Stecker; ***p. 73, top:*** Jack Newton, 20-inch f/5 reflector, Konica 3200 film, 8-minute exposure; ***bottom:*** Jack Newton; ***pp. 74-75:*** Phil Kirchmeier; ***p. 76:*** Chris Cook, 8-inch SCT at f/6.3, hypersensitized Fuji Super HG 400, 8-minute exposure on November 27, 1992; ***p. 77:*** Matthew Groshek; ***p. 78, top left:*** Charles Manion, August 12, 1981; ***top right:*** Craig Stott, 35mm lens, Ektachrome 400 film, 20-minute exposure in August 1983; ***center:*** Frances Gauger, August 11, 1983; ***bottom:*** L. Allen Beers, 50mm f/1.7 lens, Fuji HG 1600 film, 90-second exposure on August 3, 1991; ***p. 79, top left:*** Alex York and Martin Anderson, 50mm f/1.4 lens, GAF 200 film, 20-minute exposure on August 11, 1977; ***top right:*** Rick Schmidt; ***bottom:*** Mike Walters, August 1980; ***p. 80:*** Chris Becker; ***p. 81:*** Wil Tirion; ***p. 84:*** Larry Landolfi, 28mm lens at f/4, Kodachrome 64 film, 10-second exposure on February 21, 1990; ***pp. 84-85:*** Ronald E. Royer; ***p. 86-87:*** Dewey Vanderhoff, January 4, 1992; ***p. 86, bottom left:*** Christian Arsidi, 12-inch Cassegrain at f/48, Tech Pan film, 1.5-second exposure; ***bottom right:*** Gerard Therin, 4-inch f/5 refractor, Tech Pan film, $^{1}/_{1000}$-second exposure with solar filter on July 28, 1991; ***p. 87, top:*** David Palmer; ***bottom:*** Jack Newton; ***p. 88, top:*** Joshua Vaughan; ***bottom:*** Tony and Daphne Hallas; ***pp. 88-89:*** George Greaney, 5-inch refractor at f/5.9, hypersensitized Fuji Super HG 400 film, integration print made from two 60-minute exposures; ***p. 89:*** Johnny Autery; ***p. 90, top:*** Oscar Van Dongen; ***bottom:*** Scott McGurk, 1000mm lens at f/10, Ektar 25 film, 4-second exposure on July 11, 1991; ***p. 91, top left:*** Donald C. Parker; ***left center:*** Jean Dragesco, 42-inch reflector, Pic-du-Midi Observatory; ***bottom left:*** Charles F. Capen; ***right:*** Russ Sampson, 35mm lens at f/2.8, 1600 ISO film, 4-second exposure on September 24, 1987; ***p. 92, top:*** Michael F. Borman, 8-inch SCT at 4, ST-4 CCD camera, April 2, 1993; ***center:*** Ronald W. Kohl, 20-inch Cassegrain, Star I CCD camera, 3-minute exposure on March 30, 1993; ***bottom:*** Ronald W. Kohl, 20-inch Cassegrain, Star I CCD camera, 3-minute exposure on March 18, 1993; ***p. 93, top:*** Kim Zussman, 14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 95-minute exposure on April 16, 1993; ***center:*** David Hanon, 7-inch f/9 refractor, ST-6 CCD camera, composite of five exposures taken in April 1993; ***bottom left:*** Hal Jandorf, 14-inch SCT at f/6.5, 3M-1000 film, 15-minute exposure on April 8, 1993; ***bottom center:*** Hal Jandorf, 14-inch SCT at f/6.5, 3M-1000 film, 20-minute exposure made in 1990; ***bottom right:*** Hal Jandorf (composite); ***pp. 102-104:*** Darla Gawelski; ***p. 122:*** Jack Newton

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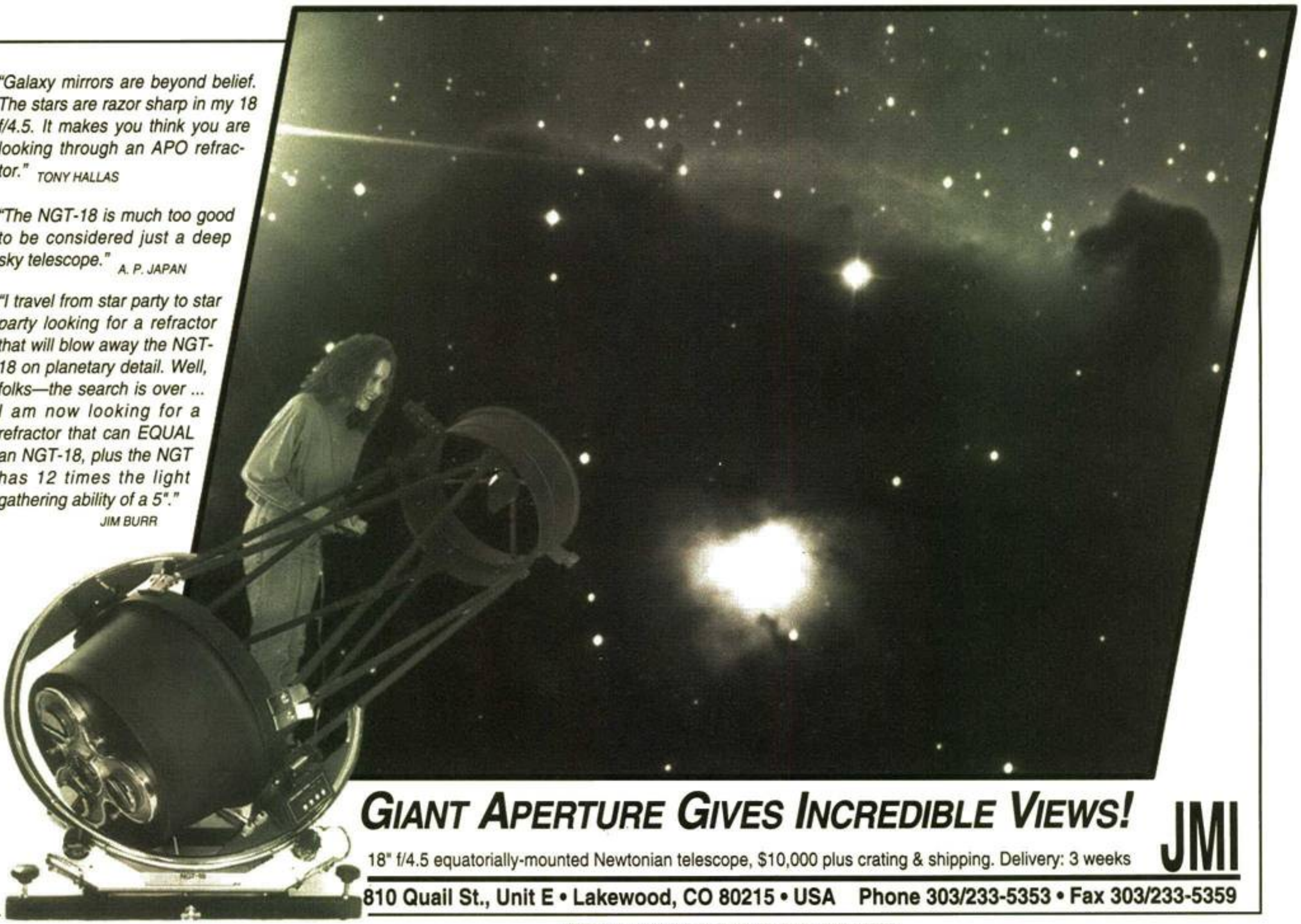

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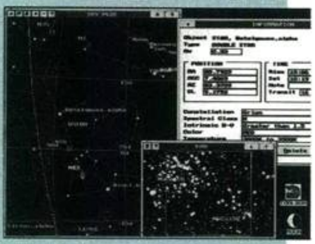

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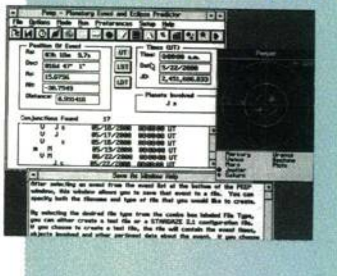

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Meetings & Events

August 2-6
The International Space Conference, Cranfield Institute of Technology, United Kingdom. Sponsored by Students for the Exploration and Development of Space. This year's theme is "International Commerce and the Space Environment." Contact: Paul Craven, College of Aeronautics, Cranfield Institute of Technology, Granfield, Bedfordshire, MK433 0AL, United Kingdom.

August 4-8
16th Meeting of Hungarian Amateur Astronomers, Kiskunhalas, Central Hungary. Sponsored by the Hungarian Astronomical Association. Write to the Hungarian Astronomical Association, P.O. Box 219, 1461 Budapest, Hungary.

August 6-7
Third Annual Star Party, Stokesville Park Observatory, Virginia. Sponsored by the Stokesville Astronomy Group. Contact: Jack Wine (706) 248-0981 or Stokesville Park (800) 626-3948.

August 7-11
The Asimov Seminar, Rensselaerville Institute, Rensselaerville, New York. This year's topic is "First Contact: The Human Impact." Write to The Asimov Seminar, The Rensselaerville Institute, Rensselaerville, NY 12147, or call Don McGrain (609) 629-3732.

August 11-15
Alberta Star Party, Eagle Lake Campground, south of Strathmore. Contact: Sylvia Smith, Edmonton Centre of the RASC, 9335-176 Avenue, Edmonton, Alberta T5Z 2C4, Canada. Phone (403) 456-4614.

August 13-14
Mt. Magazine Star Party, Mt. Magazine, Arkansas. Contact: Rex Allen McDaniel, River Valley Stargazers, P.O. Box 261, Dover, AR 72837. Phone (501) 331-3773.

August 13-14
Northwest Oklahoma Star Party, Enid. Contact: Dan Matthews, Northwest Oklahoma Astronomy Club, 1719 Pawnee, Enid, OK 73703. Phone (405) 233-5707.

August 13-14
Stellafane, Springfield, Vermont. Write to Stellafane, P.O. Box 50, Belmont, MA 02178.

August 13-15
Northwoods Starfest, Hobbs Observatory Center, Beaver Creek Reserve,

Wisconsin. Contact: Bob Elliott, Chippewa Falls Astronomical Society, c/o Hobbs Observatory, Route 2, Box 94, Fall Creek, WI 54742. Phone (715) 877-2787.

August 14
Annual Star Party, Winchester Canyon Gun Club, Santa Barbara, California. Contact: Clyde Kirkpatrick, Santa Barbara Astronomy Club, P.O. Box 3702, Santa Barbara, CA 93130. Phone (805) 966-3695.

August 14
Ohio Turnpike Astronomers Association Convention, Mahoning Valley Observatory, Newton Falls. Contact: Mark Baker, Mahoning Valley Astronomical Society, 1076 State Route 534, Newton Falls, OH 44444. Phone (216) 537-3939.

August 14
Prairie Astronomy Club Star Party, Hyde Observatory, Holmes Park, Lincoln, Nebraska. Contact: Lee Thomas, Prairie Astronomy Club, P.O. Box 80553, Lincoln, NE 68501. Phone (402) 483-5639.

August 18-22
Mount Kobau Star Party, 20 miles west of Osoyoos, British Columbia. Contact: Peter Kuzel, 4100 25th Avenue, Vernon, British Columbia V1T 1P4, Canada. Phone (604) 545-1226.

August 19-22
Oregon Star Party, Ochoco Mountains, 60 miles NE of Bend. Sponsored by Rose City Astronomers of Portland. Contact: Chuck Dethloff, 15111 NW Oakmont Loop, Beaverton, OR 97006. Phone (503) 629-2145.

August 20-22
Eastern Iowa Star Party, Wapsi River Environmental Education Center, near Dixon. Hosted by the Quad Cities Astronomical Society. Contact: Lori Brown, ALCOR, P.O. Box 3706, Davenport, IA 52808. Phone (309) 786-9622.

August 20-22
Southern Michigan Universal Regional Festival of Stargazers (SMURFS), near Clare. Contact: Richard Walker, Genesee Astronomical Society, c/o Robert T. Longway Planetarium, E. Kearsley Street, Flint, MI 48503. Phone (313) 627-9524.

August 20-22
Syracuse Summer Seminar, Darling Hill Observatory, Vesper, New York. Contact: Joseph Italiano, Syracuse Astronomical

(continued on page 122)

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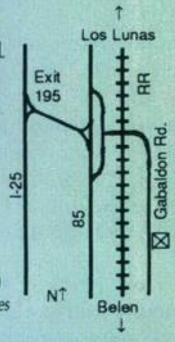

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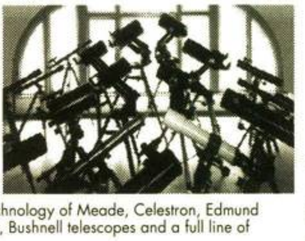

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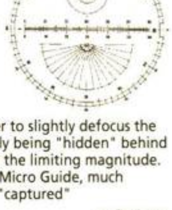

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August 20-21
Summer Spectacular, Lemon Lake County Park, Crown Point, Indiana. Sponsored by the Calumet Astronomical Society. Contact: Stephen J. Miller. Phone (219) 845-9174.

August 20-23
Nova East '93, Fundy National Park, New Brunswick. Contact: David Lane, Halifax Centre of the RASC, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6, Canada. Phone (902) 420-5633.

August 21
Jerimoth Hill Star Party, Jerimoth Hill, Rhode Island. Sponsored by the Celestial Observers of Rhode Island. Contact: Ken Conca, P.O. Box 40181, Providence, RI 02940. Phone (401) 351-5676.

August 21
Mountain Skies Starwatch, Lake Arrowhead Village, California. Contact: Lorann Parker, Mountain Skies Astronomical Society, 28200 Hwy 18 #F240, P.O. Box 1169, Lake Arrowhead, CA 92352. Phone (909) 337-4075.

August 21
Summer Star Party, Portsmouth, Virginia. Sponsored by the Tidewater Community College Planetarium Society. Contact: R. H. Stewart, 1064 Dune Street, Norfolk, VA 23503.

August 28
Northern Nights, Duluth, Minnesota. Contact: Glenn Langhorst, Arrowhead Astronomical Society, c/o Alworth Planetarium, University of Minnesota, Duluth, MN 55812. Phone (218) 389-6212.

August 30-September 3
8th General Assembly of the IUAA and **1st General Assembly of the European Section of the IUAA**, Wolverhampton, England (about 12 miles west of Birmingham). Sponsored by the Wolverhampton Astronomical Society. Contact: M. Astley, Secretary, Wolverhampton Astronomical Society, "Garwick" 8 Holme Mill, Fordhouses, Wolverhampton, West Midlands WV10 6LZ, England. □

Clubs, please submit meeting announcements at least four months before the event. Readers, when you write to organizations listed here, please include a self-addressed, legal-sized envelope with your request for information.

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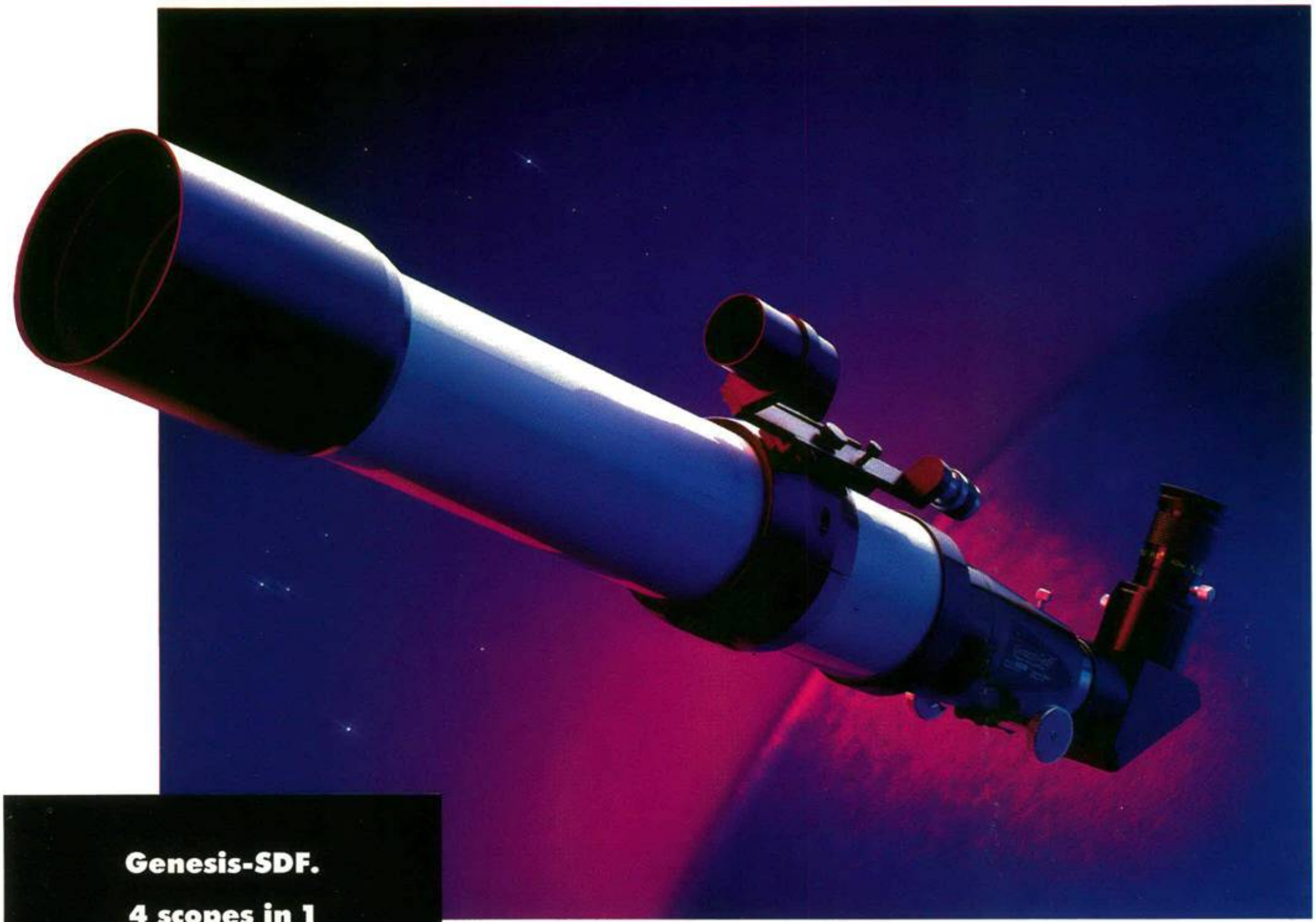

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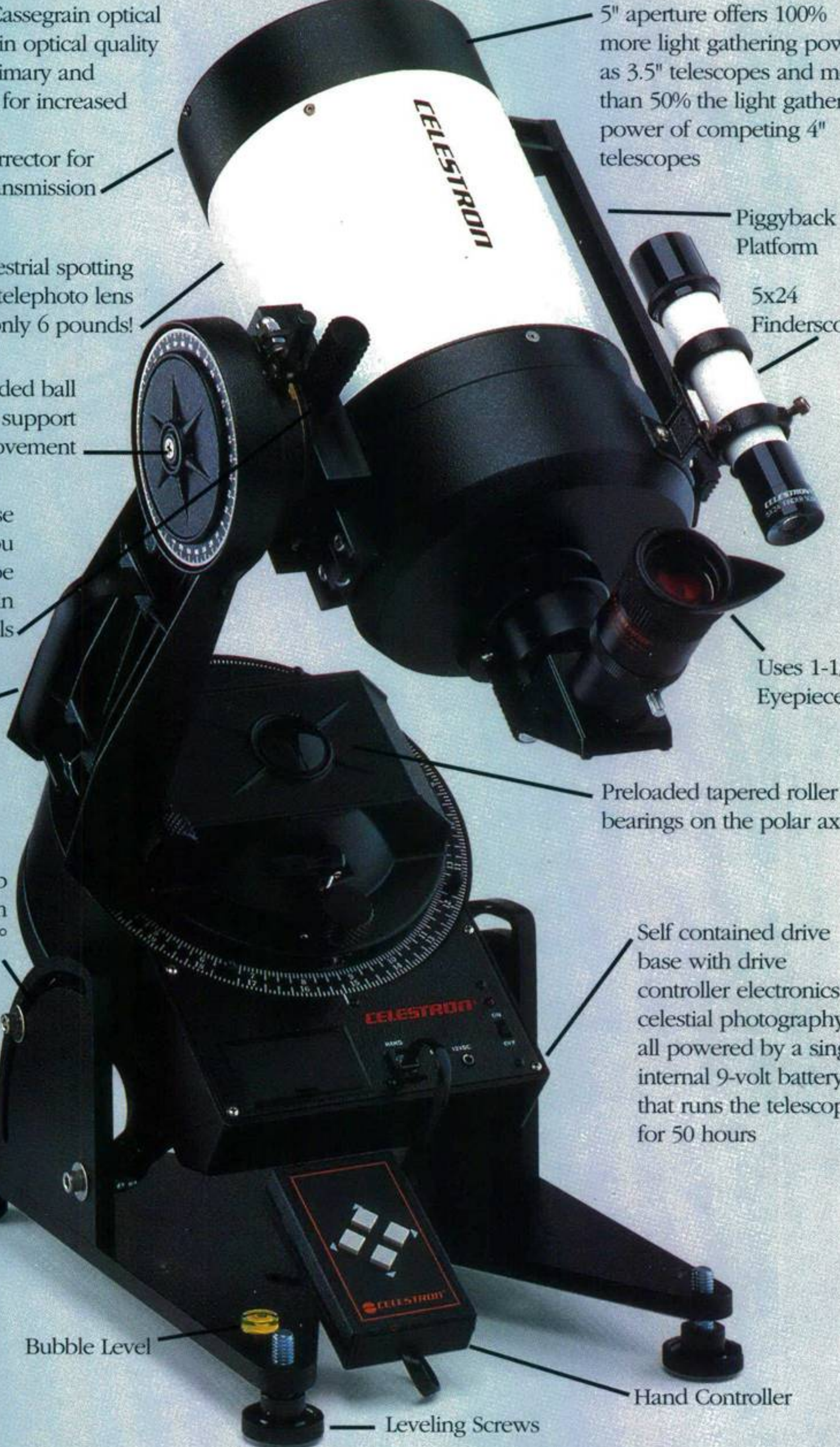

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